THE AGRICULTURE

OF THE

UNITED PROVINCES

AN INTRODUCTION FOR THE USE OF LANDHOLDERS AND OFFICIALS

BY

W. H. MORELAND, B.A., LL.B.

of the Indian Civil Service.

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PREFACE.

THE welfare of the cultivator may be affected for good or for evil by the actions of two distinct classes, the officials with whom he has to deal and the landholders (or their subordinates) under whom he holds his land. The two classes have at least one feature in common, that they know very much less of the cultivator's business than he knows himself. It is true that an observant man may, in the course of time, collect a mass of information on the subject, but the process is in any case slow, the power of independent observation is comparatively rare, and thus it happens that even experienced land agents and officials may do a great deal of harm merely from ignorance and thoughtlessness. The present volume has been compiled with the object of supplying an introduction to the subject which may be of use to all who have to deal with the cultivator, not by saving them the trouble of observing for themselves, but by furnishing them, so to speak, with a framework on which they can arrange the knowledge they acquire.

The book is divided into two parts: the first aims at giving a general account of the subject, while the second gives some details concerning the different agricultural regions of the provinces, and the various crops that are grown. The method of description adopted in the opening chapters calls for a word of explanation. Even in England it is not possible to assume that a well-educated man is familiar with the elementary principles of science which explain and

justify the empirical art of agriculture : and in India at the present day it is generally safe to assume that a knowledge of the principles of science is altogether wanting. But it is not possible to give even an elementary view of agricultural practice without referring to such subjects as the behaviour of water in soils, the collection and dissipation of nitrogen, and a few other fundamental matters : and it has on the whole seemed the best course to begin the subject by a broad statement of principles, which will be truisms to a reader with scientific training, but must be taken as axioms by those who have not enjoyed that benefit. If the scientific reader finds that the principles have lost some of their completeness in the process, the writer can only apologize for the defect, which indeed appears to be inherent to a greater or less extent in the treatment of the subject which has been adopted.

In a work of this kind it would be pedantic not to use the vernacular terms which are current in every-day conversation. I have used English names where they express clearly the nature of the thing or process to which they are applied, but in other cases I have preferred vernacular terms to cumbrous paraphrases. A glossary will be found at the end of the volume.

I have indicated in notes at the end of several chapters the books of which I have made most use, and which appear likely to assist readers who wish to pursue the subject further ; but I must express my special obligations to Messrs. Fuller and Duthie's monograph on the Field and Garden Crops of the Provinces. I have also to acknowledge the cordial assistance I have received from my colleague Mr. J. M Hayman ; and also from Mr. S. H. Fremantle,

Indian Civil Service, who has supplied me with much information on Bundelkhand affairs, and has by his criticisms enabled me to improve the earlier chapters in numerous details.

It is perhaps desirable to add that the views on matters of policy, which appear in the chapter on the management and improvement of estates, are offered on my own responsibility, and do not claim to represent the attitude of the Government under which I am privileged to serve.

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PART I.

GENERAL ACCOUNT.

CHAPTER I.

THE GROWTH OF PLANTS AND THE WAY IN WHICH IT CAN BE INFLUENCED BY THE CULTIVATOR.

Preliminary Explanations.

The term *agriculture*, which means literally the tillage of the soil, is generally understood as including not only the growth of crops but the rearing of animals to supply human food. In Northern India, however, the consumption of meat is so unimportant that this branch of the art may be neglected: we are concerned with animals only as (1) workers, (2) manure-suppliers, (3) milk-yielders; and apart from these matters our attention may be confined to the growth of crops.

The main object in growing crops under the conditions now prevailing is to feed the grower and his family, as well as the animals employed in tillage: the second object is to produce something for sale in order to procure money for clothes, for rent (where this is not taken in kind), and for the incidental expenses of the household. These objects contribute to determine the area put under the different classes of crops, a point which will be considered later on. We must first make sure what we mean by the expression

"to grow crops." Now the knowledge which has been collected on this subject cannot be fully grasped without a preliminary study of several branches of science; and readers who do not possess the requisite knowledge of physics, chemistry and physiology must be content with a partial explanation. The rest of this chapter aims at stating in plain terms a few of the principal conclusions that have been reached on this subject. Proofs of these conclusions must be looked for elsewhere: they can be stated here only as axioms on which to found an explanation of the cultivator's conduct and of his needs.

What the cultivator does.

In the first place then it is not strictly accurate to say that a man "grows crops" or "makes crops grow." Given certain conditions, plants grow of themselves whether man interferes or not: if some of those conditions are wanting, no amount of interference (short of actually supplying the defect) will make the plants grow. The point is important, for its clear comprehension enables us to see the part actually played by the cultivator. Plants grow in their own way: the cultivator intervenes to make the conditions of growth as favourable as possible for the attainment of the object he desires. We have then to ascertain the conditions of growth, and having done so, to see how they can be affected by the action of the cultivator.

Stages of development.

In the development of ordinary farm plants there are three distinct stages, which may be called *germination*, *growth* and *ripening*. An ordinary seed can be kept for a

long period without undergoing a material change; but when a cultivator sows seed in his field, the great majority of the seeds are expected to yield plants: the seed puts out a small shoot or shoots, and the beginnings of a root, and at the same time begins to shrink in size.

Germination.

This is germination: what has happened is that the plant has begun to grow from the seed and to use up in its growth the material stored in the seed. A healthy seed requires for germination (1) a suitable temperature in the soil where the seed lies, and (2) a certain amount of moisture in the soil; these conditions will not however induce germination in an unhealthy seed, so that the choice and preservation of good seed are essential to success. The ordinary operations of tillage and sowing are directed to secure suitable conditions of moisture and temperature, as will be explained later on, but it may be noticed here that the soil as such is not a condition of germination: we can make seeds germinate by placing them on a damp tile or in a damp piece of cloth and keeping them at a certain temperature.

Growth.

The second stage of development is marked by the increase in size of the plant, both in the surface growth and in the roots. It is obvious that a maize seed (for instance) does not contain all the matter which goes to form the mature plant: by far the greater portion of the plant has come from sources outside the seed, and the art of cultivation so far as this stage of development is concerned lies in putting the plant in a position to secure the matter which

it needs. The first requisite of the growing plant is stability, as plants do not grow satisfactorily in any but their natural position. Stability depends on the way in which the soil has been prepared: the particles must be close enough together to support the plant through its roots, while not so close as to prevent the roots from growing. This condition of the soil is influenced by the kind of tillage adopted.

Plant food.

The matter taken up by the plant can be conveniently described as "plant food;" it feeds the plant just as a man is fed by the food that he consumes. There is, however, a marked difference between the methods of feeding adopted by plants and by animals: an animal takes in its food solely through the mouth, which also serves to supply most of the air it needs: a plant takes in one kind of food through its leaves and green stalks, and other kinds along with water through its roots, while it breathes air through a large part of its surface (including the roots).

Food from the air.

The substance taken in through the leaves is a gas contained in the air which is usually called carbonic acid gas. This gas is produced by all animals when they breathe, by fuel when it burns, and by animal and vegetable matter in decaying, and there is always enough of it in the air to supply plants with what they need. The cultivator therefore does not take any measures to increase the supply of this gas; but he has to see that the plants are not so crowded as to prevent a free supply of fresh air to each

individual. The plant, however, cannot utilise this gas under all conditions though it may be present in the atmosphere; the actual manner of its utilisation is not known, but so much is known that it is consumed only in those parts of the plant which are coloured green, and only under the influence of sunlight. The cultivator has therefore to see that his plants get a fair supply of sunlight; he cannot of course affect the weather conditions, but he can so arrange his plants that the light reaches all the green parts of them. When this is the case, the carbonic acid gas is transformed into other substances, which go to build up the plant. These substances are very numerous, and change into one another in ways that cannot be discussed here: various forms of starch and sugar are perhaps the best known.

Water.

The substances taken up by the roots are first water and secondly certain things dissolved in the water. The soil is composed of small particles of matter, each of which is ordinarily enclosed by a thin invisible film of water: the particles of the soil are not packed tightly together but separated by spaces which usually contain air, though if there has been heavy rain they may be more or less choked by water. The roots pass through these spaces, and the minute hairs which can be seen growing out from them are in contact with the particles of soil and take up water from the films surrounding them. This water passes through the plant; some of it is used in building up the substances into which, as has been explained above, the carbonic acid gas is transformed, the rest is evaporated from the leaves in the form of vapour and passes into the air. More water drawn

through the roots replaces what is used up or evaporated, and thus there is a stream of water travelling upwards from the roots to the leaves.

This water with the substances dissolved in it constitutes the sap of the plant: the actual mechanism of its movements cannot be explained without a somewhat elaborate scientific discussion, but the movement is essential to the life of the plant. If the supply of water in the soil is insufficient, the effect is seen in the withering of the plant, and one of the main objects of tillage is to regulate the supply as far as possible.

Minerals.

Almost the whole bulk of the green plant is composed of substances built up out of water and carbonic acid gas, the former taken up by the roots and the latter by the leaves. But the plant cannot live on these substances alone: it requires in addition small quantities of various other substances, which it obtains from the soil, and though the quantity required is so small, any deficiency in the supply has a most injurious effect on the plant.* The most important needs are substances which bear the names of (1) *potash*, (2) *phosphoric acid*, (3) *nitrates*; lime, iron and sulphur are also required, but the supply of these latter substances in the soils with which we are concerned is in practice never found to be deficient, and we need not consider them further. As regards the other three, it may be said broadly that potash and phosphoric acid are obtained from the mineral contents of the soil, and nitrates from other sources, which will be described later.

* The effect of very small quantities of certain substances is not an isolated phenomenon: we see something of the same kind in the need experienced by human beings for small quantities of salt.

As has been said above, the soil is composed of small particles packed more or less loosely together : some of these consist of vegetable matter in a state of decay ; but the bulk of the soil is *mineral*, that is, it consists of fragments of rocks which have gradually been broken up carried by water (and to a less extent by wind), and dropped in a position more or less distant from the source. Thus the soil of the duab has been gradually deposited by the rivers flowing from the Himalayas, and consists of fragments of the rocks which form those mountains ; while most of the very distinct Bundelkhand soils have been similarly produced from the mountains of Central India. Rocks are composed of a large number of substances and differ materially in composition : the commonest substance is what we know as sand, which makes up 70 to 90 per cent of the total weight of soil. In the rocks much of this sand is combined with other substances, among which are potash and phosphoric acid ; and it is from these complex minerals that the plants derive their mineral food. But it is important to notice that these complex minerals are not as a rule soluble in water : a stone placed in water does not dissolve in the same way as a piece of salt : and as long as the minerals are not dissolved in water the plant cannot make use of them. It is, however, found that these complex minerals do not remain permanently unchanged in the soil, but that small particles of them when exposed to air and water gradually decompose and leave the potash and phosphoric acid in a soluble form. The particles of the soil are, as has been said above, surrounded by a thin film of water, and any soluble substances forming on their surfaces are at once dissolved in this. Thus, as the potash or

phosphoric acid is set free from the complex mineral containing it, it passes at once into the soil water, and becomes available for the plant. The mineral matter of the soil may thus be regarded as a store of these substances, gradually yielding them up in small amounts. The cultivator can to some extent increase the rate at which this process is carried on by "breaking up" the soil as it is called, thus quickening the decomposition of the complex minerals. But it is not to be supposed that all soils are alike either in the amount of these minerals which they contain or in the rate at which they yield the desired substances. In many parts of the world soils do not contain sufficient soluble potash or phosphoric acid to give good crops, and the natural supply must be supplemented by special manures: these may also be necessary when it is desired to get exceptionally large crops off ordinary soil. In such cases, if the soil is deficient in the supply of phosphoric acid, it is usual to apply bone-dust, superphosphate or some similar manure containing what is required, while if potash is in defect, saltpetre, kainit or some other mineral containing potash is added. As a general rule, however, the soils of these provinces when carefully cultivated yield as much potash and phosphoric acid as is required by ordinary crops, and the application of such special manures is unnecessary, while their cost is prohibitive. Saltpetre, however, is occasionally used, as will be seen in the chapter on manures.

Nitrates.

Finally we have to consider the supply of nitrates, the most important matter of all so far as these provinces are concerned. The substances known as nitrates consist

essentially of nitrogen in combination with various other substances. Now nitrogen is a very common gas, making up about four-fifths of the air, but *combined* nitrogen is by no means so common. The distinction indicated by the use of the word *combined* will be familiar to readers who have studied chemistry: it cannot be explained without some knowledge of that science, but it may be illustrated in various ways. Thus ordinary sugar may be regarded as a combination of charcoal and water; that is to say, it is possible to take 23 lbs. of sugar and separate it into 12 lbs. of charcoal and 11 lbs. of water: but you cannot make sugar merely by mixing these substances together. Or, again, if you mix sand with common washing soda, you can still recognise the two substances in the mixture; but if you heat the mixture strongly, the two substances disappear and glass is formed in their place: that is, they are now combined to form a new substance.* Now the enormous quantity of nitrogen contained in the air is as such of no use to ordinary plants, but combined nitrogen in the form of nitrates is absolutely essential to their growth: that is to say, plants cannot use the nitrogen in the air as they use the carbonic acid gas; it must first enter into the state known as combination. Unfortunately for the cultivator, this is very difficult: so far as is known nitrogen enters into combination only in two ways that can benefit him. The first way is under the influence of electricity, and as a matter of fact a certain amount of combined nitrogen is formed in the air during thunderstorms, and is brought on to the earth in rain. Small as is the quantity so formed, it

* The process is in reality not quite so simple as stated in the text for purposes of illustration.

represents a substantial supply of plant food, though it is not enough to replace what a crop takes off the land. The second source of combined nitrogen is found among some very minute living beings, which inhabit the soil in enormous numbers : some of these beings, which can be seen only with a powerful microscope, will under certain circumstances feed on the nitrogen of the air, and produce combined nitrogen from it, and though each individual is so small, the enormous number present in the soil make this source of supply most important.

Now the cultivator obviously cannot employ electricity to produce combined nitrogen,* but he can aid the growth of these minute beings, which we may speak of as bacteria : so far as is known these beings, though existing in the soil, can thrive and multiply only among the roots of certain kinds of plants belonging to what botanists call the leguminous order : this group includes plants such as gram, peas, arhar, urd, hemp and other crops, as well as certain trees, so that the cultivator can get a supply of combined nitrogen by growing these crops. If you carefully dig up a growing gram or arhar plant and wash the roots free from earth, you will find them to bear small knots or lumps : these knots or lumps, which are known as nodules, are the homes of the bacteria in question, and where they are found they indicate that the soil is being enriched in combined nitrogen.

These two sources are so far as is known the only ways in which fresh supplies of combined nitrogen are obtained from the nitrogen of the air, though it is possible that other

* As a matter of fact an industry of this kind is being talked about in America, and it is conceivable that at some future time the power developed by the great rivers of the provinces may be devoted to this object.

agencies may be at work which have not yet been discovered But in addition to the fresh supplies of combined nitrogen from these sources there is an enormous stock in existence, much of which is used over and over again : the circulation of this stock is a matter of the greatest practical interest. What we have spoken of as combined nitrogen is really a large group of substances having the common feature that they contain nitrogen in combination. To give a list of these substances would be to enumerate perhaps the majority of familiar objects : combined nitrogen is contained in flesh, in flour and in milk ; in skin and bone ; in dung and urine ; in wood and coal, and so on. Yet other forms are what we know as smelling salts, as saltpetre, etc., etc. Now if we consider together all the nitrogenous substances obtained from animals and plants, we see that they are used up in one of three ways : they may be eaten by animals, they may be burnt, or they may rot. If eaten by animals, the nitrogen remains combined, and eventually it will either be burnt or rot. In burning, the combined nitrogen is destroyed, and the nitrogen returns to the air in its original condition, hence every time that any nitrogenous substance is burnt there is a loss to agriculture. The loss is least when the fuel consists of substances such as coal or wood, which contain proportionately little nitrogen ; it is greatest when the substance is rich in nitrogen. The commonest loss in these provinces is from the use of dung as fuel : it is unavoidable under present conditions, as fuel is a necessity of life, and wood or coal are not available for ordinary people ; but the fact of loss should be clearly recognised. The process of decay is that which interests the farmer most closely : most

of the substances we have enumerated contain the nitrogen in a state which plants cannot use; but when they are left alone in moist air, they are at once attacked by various bacteria which live on these substances, and which are present practically everywhere. These bacteria are of different kinds, and the results of their work are accordingly different. Some give off *free* nitrogen: they are of course hurtful to the farmer, just as if the substance was burnt. Some give off a substance known as ammonia; it has a well-known pungent smell which can usually be recognised about manure heaps, cattle sheds and the like. Some of this passes into the air, and is temporarily lost, but eventually returns to the land with the rain: the rest is attacked by yet other species of bacteria, which at length convert it into the forms known as *nitrates* (saltpetre is the commonest of these), which are soluble in water and can be used by the plant. The plant takes up the nitrates in the water and uses them to build up other substances, and so the circulation goes on.

This subject is of such vital importance that it may be further illustrated. Suppose a crop of wheat has taken up 20 lbs. of nitrates. Perhaps 18 lbs. of these will be worked up into substances stored in the grain, a pound will remain in the straw, and a pound in the roots. The roots will decay in the field, that is, the one pound of nitrate returns to the field as combined nitrogen, to be worked up again by the bacteria of the soil. The straw will be eaten by cattle, and the combined nitrogen in it will either go to form flesh, milk or hair, or will pass out in urine or dung. The dung may be burnt: if so, the combined nitrogen is lost; or it may go to the manure heap, where it decays, and the

combined nitrogen (or some of it) is worked up again into nitrates for the land. When the cattle die, probably the flesh and hair will be allowed to decay and their nitrogen similarly worked up into nitrates. The milk will be consumed by other animals and the nitrogen in it disposed of in the same way as that contained in the straw. Finally the grain also will be consumed and the nitrogen in it will either be lost or will return to the land in the manner just indicated, there being in this respect no difference between the functions of human beings and those of animals.

The practical lessons to be learnt from these considerations are as follows :—

In the first place, no product of animal or vegetable life should be burnt if it can be left to decay without risk of injury to health : in the second place, the decay should be so regulated as to lose as little nitrogen as possible ; and in the third, care should be taken that the products of decay reach the soil, and are not carried away into the rivers. The means of securing these objects will be considered in the chapter on manuring.

Respiration.

So much may be said regarding the food taken up by the plant : in addition it requires air which in ordinary plants is breathed through minute openings in the surface both of the roots and of the upper growth. For the latter no precaution is necessary, but it is most important to see that air has free access to the roots. If the soil is caked into large masses, or if the spaces between the soil particles are choked by water, the access of air will be hindered : here again thorough tillage is necessary, while if there is risk of

waterlogging, drainage may also be required. A special class of plants, however, is adapted to life in water or water-logged soil, having arrangements (which cannot be described here) for the supply of air in other ways. Singhara belongs to this class of plants, but the most important is rice. The modifications in ordinary tillage required for growing rice will be mentioned in the section dealing with that crop.

Ripening.

The final period in the development of an ordinary plant is occupied by the ripening of the seed or fruit. First the plant flowers, and the flowers develop into seed or fruit, the leaves at the same time tend to lose their green colour and turn yellow or brown. A flower may be either a bright, conspicuous object as in peas or flax, or it may be small and inconspicuous as in wheat or juar, but in all cases two elements, the male and the female, must combine to form a perfect seed. The male element can usually be seen as yellowish dust (known as pollen), while the female element is not visible in an ordinary flower but is contained in a receptacle which can be seen usually at the base of the flower. In order that seed or fruit may be formed the pollen must reach this receptacle, and this is accomplished in a great variety of ways, of which we can here give only a few instances. The simplest case is where both the male and the female elements grow in one flower and the pollen falls direct on to the female receptacle. This is the case with wheat and some other cereals. If we open one of the small flowers on a newly formed ear of wheat we find inside it three upright yellow spikes and a white, feather-like thing

at the base. These spikes are bags containing the pollen, while the feather-like thing is the receptacle : if the flower is opened early on a bright morning, we can often see the pollen-bags burst open and the yellow powder contained in them fall on to the receptacle. Once there, it penetrates inside, and so fertilises the flower. Another type of fertilisation is found in maize : here the male and female elements grow on different parts of the plant : the "spike" at the top contains the pollen, while the receptacle is indicated by the tuft of hairs which grows out in one or more places on the stem. In this case the pollen gets into the air, and thence falls on to the receptacle, so that as a rule each plant is fertilised by the pollen of some other plant, while in wheat each flower fertilises itself. In the pea, again, the male and female elements are in the same flower, but fertilisation is usually effected by insects, which carry the pollen from one flower and place it on the receptacle of the next : of course they do not do this intentionally, but the shape of the flower is such that when the insects enter it for the sake of the honey or nectar it contains, the pollen falls on their bodies, and is then brushed off when they visit another plant.

The cultivator cannot interfere with advantage in the fertilisation of ordinary plants, though in some parts of the world he has actually to arrange for the fertilisation of flowers of certain fruits, such as figs and dates ; but the subject is of practical importance in that any hindrance to fertilisation will have an injurious effect on the crop. Heavy rain, for instance, just when maize is flowering, will wash much of the pollen off the plants and out of the air, and some of the plants will be imperfectly fertilised : in this

case the plants will look healthy enough, but the cobs will develop imperfectly and the quantity of seed produced will be lessened. Such injury is likely to be greatest where the flowers are open, and least in crops such as wheat, where fertilisation takes place within the closed flower.

Contents of seeds.

After fertilisation the seed or fruit gradually develops within the flower. A seed must contain first the germ or living element which will under proper conditions start the growth of a new plant, and secondly enough food for the germ to live on until it has sent out roots and begun to collect food for itself. This food is produced in the parent plant from the materials that it has collected from the soil or the air, and passes into the developing seed : large numbers of different substances are stored in this way by different plants, but they can be grouped in two main classes according as they do or do not contain combined nitrogen. We shall see further on the importance of these two classes of substances in animal nutrition ; here we will merely say that the non-nitrogenous matter is usually either *starch* or *oil*, while the nitrogenous matter is in various forms which are known collectively as *albuminoids* or *proteids*.

Various products of plants.

It is usually at this point that man steps in and takes for his own use the substances which have been stored for the growth of the next generation of plants. Seeds such as wheat or maize, containing starch and proteids are used for human food : while seeds such as linseed, which contain comparatively small amounts of starch but much oil, are

made to give up the latter substance. In a few cases seeds are used not for their store of food but for some accessory. The commonest of these is cotton: just as many grass seeds have long feathery processes attached to them to enable them to be carried about by the wind, so the seed of the cotton plant is covered with woolly fibres, and it is mainly for the sake of these that the plant is cultivated. The poppy again forms in its seed capsule a particular kind of drug, which is extracted as crude opium.

Whatever may be the products for which the plant is grown, it is a general fact that the quantity stored depends on the health of the plant. Wheat grown in land which contains insufficient plant food, or an inadequate supply of water, will yield small, thin seed, and also a small number of seeds to each plant. The weight of seed obtained from an acre will therefore be much less than in the case of a properly nourished crop. A starved poppy crop again will give a small yield of opium, a starved linseed crop a small yield of oil, a starved cotton crop a small yield of fibre. And not only will the yield be smaller but the quality of the yield will commonly be poorer: the cotton fibre will be deficient not only in weight but also in length and strength, and so on.

Special types of crops.

The account which has been given above of the development of a plant applies in its entirety only to those plants which are known as annuals, that is to say, those which produce their seed at the end of the first season's growth and thereafter ordinarily wither and die, or at least do not produce a second yield of seed. This is the case with the

great majority of farm plants such as wheat, rice, barley, the various millets, and the pulses. In some cases, however, the cultivator does not wait for the ripening stage, but cuts the plants during growth: this is done with juar grown for fodder, and occasionally with other plants grown for the same purpose; with tobacco, which is grown for the leaves, and with some green vegetables or salads. Further, there is a type of plant which only yields its seed in the second season of growth. During the first season these plants grow in the ordinary way, but instead of forming seeds they store up the food which they have gathered in a form in which it will remain available during the second season: the plant then ceases to collect fresh food, and lives on what it has stored up until its seed is matured. In this case the cultivator's object is to facilitate the storage of as much food as possible, and then at the end of the first season take the store for his own use. The store is usually formed underground in the roots or the lower part of the stem as with radishes and turnips: the amount of storage depends mainly on the facilities which the plant has for collecting food, and consequently the principles of cultivation are generally similar to those already indicated for annual crops.

The case of the sugarcane is somewhat exceptional, as the plant can live for several years: this plant during the season of growth stores up food in the form of sugar, which it consumes later on: here the food is stored not in the roots but in the canes. The cultivator prefers to cut it at the end of the first season and extract the sugar so stored.

There is further a large class of plants known as "perennial", which yield seed or fruit year by year for periods of varying

length, the plant continuing to live on. Trees come under this class, and the cultivator is mainly concerned with fruit trees such as the mango, the guava, etc. The special features of the growth of these perennials will be dealt with in the chapter on tree-planting.

Summary.

From the account which has now been given of the growth of plants it will be seen that the cultivator has many points to attend to: the principal needs and the methods by which they are attained are summarized in the following table —

Needs of the plant.	Operations to meet these needs.
1. Good seed	Choice and preservation of seed.
2. A suitable seed bed ...	Tillage: occasionally irrigation.
3. Support for the plant	Tillage.
4. Room for development	(1) Method of sowing: (2) weeding.
5. Supply of water ...	Directly—irrigation or drainage. Indirectly—tillage and manuring.
6. Mineral food ...	(1) Tillage, (2) manuring, (3) rotation of crops.
7. Combined nitrogen ...	
8. Air for the roots ...	Tillage and drainage.

It will be seen then that the tillage of the soil may affect almost all the conditions of development: this is the most important part of the cultivator's work, and will be con-

sidered before the more special operations of sowing, weeding, irrigation, manuring and selection of suitable crops in rotation. But when the cultivator has done all he can, the weather still exercises a controlling influence on the success or failure of his efforts: we will therefore begin our description of the agriculture of the provinces by a short statement of the type of weather that may be expected and of the effect that unseasonable weather may produce.

Notes to Chapter I.

(*a*) The following figures will help to give an idea of the extent to which mature plants consist of the different things they have taken up: but it must be remembered that water is constantly being given off by the plant, and therefore the amount of water it has used is far more than what remains in it at maturity. A crop of wheat which I saw growing gave about 2,000 lbs. of grain and 3,000 lbs. of straw (bhusa) to the acre. The total weight of the crop removed from the land was thus about 5,000 lbs. Out of this about 600 lbs was water, 1,200 lbs. woody fibre of little use for food, and over 500 lbs. miscellaneous substances (including a little oil). The things really useful as food were: starch (and substances of the same kind), 2,000 lbs., albuminoids (*i e.*, nitrogenous matter) 300 lbs., and minerals about 350 lbs Two thirds of the strach and albuminoids were in the grain and one-third in the staw: on the other hand nearly all the minerals were in the straw, but most of this was sand, which is of no value as food. If we enquire what plant food this crop took from the soil, we shall find it was about 50 lbs. of nitrogen, 20 lbs. of phosphoric acid, and 30 lbs. of potash. That is a heavy crop for this part of the country, and other field crops will take rather less.

We may contrast this with a crop of potatoes: we may assume that the stalks are left on the land, so that only the potatoes themselves have to be considered. We may hope to get 10,000 lbs. weight of these from an acre with a moderate amount of manure: this would include not less than 8,000 lbs. of water and 1.700 lbs. of starch. About 100 lbs would be mineral, and albuminoids would be rather less. Such a crop would take from the soil perhaps 30 lbs. nitrogen, to lbs. of phosphoric acid, and 40 to 50 lbs. of potash.

Such extraordinary differences in the value of crops are very important when we come to say what is a proper diet either for man or for animals: for instance, a man eating a seer of wheat grain, made into ata, will get 11 chittacks of starch and 1½ chittacks of albuminoids, while a man who eats a seer of potatoes gets less than three chittacks of starch and not ⅛ chittack of albuminoids.

It is also desirable to get a rough idea of the actual amounts of the different materials present in the soil. These amounts are usually stated in percentages, but for purposes of illustration it is more convenient to consider a definite block of soil. We may take for this purpose a square yard of ground and examine the soil to a depth of one foot: such a block will weigh roughly about 800 lbs. If the soil be bhur, about 750 lbs. will consist of sand and other minerals with which we are not directly concerned: about 30 lbs. may be alumina and about 3 lbs. lime. Thus the ingredients of the greatest importance will weigh only about 17 lbs. Out of this nearly 13 lbs. will represent organic matter: and there will be about 4 lbs. of potash and not more than half a lb. of phosphoric acid. The 13 lbs. of organic matter will probably contain not more than half a lb. of nitrogen at the outside, so that the crops on this block of land have just 5 lbs. in all of the principal plant food (4 lbs. potash, ½ lb. phosphoric acid, and ½ lb. nitrogen).

If we take a clay soil, the amount of plant food will be approximately the same except that there may be as much as a lb. of phosphoric acid: the difference in composition between the two soils is seen in the alumina, which will probably amount to from 60 to 80 lbs.; there will also usually be more lime, probably as much as 10 lbs.

A loam, on the other hand, will probably contain about 47 lbs. of alumina and 7 or 8 lbs. of lime. The amount of potash and of phosphoric acid will be very much the same as in the clay, and that of nitrogen very little greater, very rarely as much as ¾ lb. in all.

It is noticeable that while an ordinary bhur soil may contain 750 lbs. of sand out of a total weight of 800 lbs., even a stiff clay contains as much as 600 lbs., or three-quarters of its whole weight. It is thus easy to see why the size of the soil particles is of such great importance, as even the heaviest clay is three-quarter sand.

(*b*) The reader who desires to study further the subject of plant growth will find a very complete introduction in *Agricultural Botany*, by John Percival (London: Duckworth & Co.). A thorough recent treatment of the subject will be found in *Vegetable Physiology*, by Professor Reynolds Green (London: J. and H. Churchill).

CHAPTER II.

THE WEATHER.

Introductory.

The ordinary type of weather in the provinces is so well known that a brief description will suffice. Rain sets in about the end of June, and from then till the end of Sep-

tember the air is full of moisture, and rain occurs on the average about once in three days. As a rule, the rain comes in bursts: there will be heavy rain for two or three days together, and then an interval of finer weather. The actual amount of rain received in this period varies with the locality: it is largest in the districts lying under the Himalayas, and among these it is greater towards the east. Further south the rain diminishes from east to west and also from the north to the line of the Jumna river. The smallest rainfall is received in a strip of country of varying width lying along this river and extending roughly from Aligarh and Muttra to the south of the Fatehpur district: further south in the Bundelkhand districts the rain is usually heavier. The weather clears about the end of October, and rapidly becomes colder until January. Light rain is often, but not always, received between December and February, and after the latter month the temperature rises rapidly, and no more rain can be expected till June except in the way of thunderstorms.

Seasons.

The year is naturally divided into two seasons, the kharif and the rabi. The former begins in June or July, the latter in October. In the former are grown those crops which need a high temperature and a large supply of water, in the latter those that require cooler weather and a moderate supply of moisture.

Distribution of rainfall.

Perhaps the mistake most commonly made in estimating the character of the season is to judge by the total amount

of rainfall without considering its distribution in point of time : the distribution is usually the more important consideration of the two. The following may be taken as an ideal distr ibution in those parts of the provinces where rice is not largely grown. To begin with there should be some rain at the end of May or the beginning of June, so that ploughing can be started as soon as possible. Next, heavy rain is wanted in the end of June to get the land thoroughly wet, followed by a week or so of fine weather for tillage and sowing. The rest of July and August should be marked by occasional heavy falls with bright intervals between, but no interval should last longer than a week or ten days. Similar weather with perhaps rather less rain is wanted in September, but towards the end of this month there should be one or two heavy falls of rain to get the land ready for rabi operations. Where late rice is largely grown this distribution should be somewhat modified : on the whole, more rain and less sunshine are wanted ; there should be at least one very heavy fall of rain towards the end of July, and two or three heavy falls in August and early September, while a final fall in the early part of October is most desirable.

So much for the kharif season. For the rabi the first requirement, assuming that the September rains have left sufficient moisture in the soil, is that the air should cool down rapidly so that the soil may fall to the proper temperature for germination. This cooling occurs most rapidly when the wind is moving steadily from the west and the nights are free from cloud. During November and the early part of December the weather should remain clear and get steadily colder ; but soon after the middle of

December a light fall of rain is beneficial. A second fall is desirable in the first half of January, after which the eastern half of the provinces will want no more rain, while a further light fall in February will benefit the western districts. It is of the utmost importance that the cold weather rain should not extend over a long period, but that the showers should be followed promptly by clear weather: a continuance of damp cloudy weather in January and February is almost sure to have a disastrous effect by promoting the spread of various plant diseases. The rest of the season should be dry and (especially) free from hailstorms: the west wind must be expected to blow strongly during March, but it is an additional advantage if its strength is moderate. As soon as the rabi crops are harvested rain will do great good, benefiting the young sugarcane and other standing crops and enabling the cultivator to start his ploughing for the next year.

A year of the type sketched above will enable the cultivator to till his soil to the best advantage and to obtain on the whole good crops: the reasons why certain kinds of weather are important at particular times will appear in later chapters; for the present the statements which have been made must be accepted as based on experience. It must be remembered too that there is usually some conflict of interest between different crops and also between individual cultivators. Thus late rice may be enormously benefited after a dry season by a fall of rain late in October, which may at the same time have disastrous effects on the rabi: whether such a fall is a benefit or the reverse in any locality depends on the relative importance of late rice, and relative importance may in ordinary cases be measured roughly by

the area under the crop. Or again, when rain falls in the middle of December it will be of great benefit to crops which have not been irrigated, but may even do harm in fields which have been irrigated a few days before. Thus, whatever may happen, you will always find individual cultivators ready to grumble, and usually with good grounds : what benefits the locality as a whole may cause loss to individuals, while, on the other hand, individuals may derive benefit from the calamities of their neighbours. Such considerations are often of great importance in connection with the realisation of rent and revenue.

Effect of abnormal weather.

An endeavour should be made to foresee the probable effects of abnormal weather : the remarks which follow summarize the experience that has been gained on this subject. Dealing first with the kharif season, there is the case when no rain falls between June and September. This actually occurred in 1877 over some parts of the provinces. In this case it may be possible to bring a few fields to maturity by the aid of irrigation, but the heat is likely to be so great that the ground will dry very quickly : a field will need three or four times the amount of water that would be required in the cold weather, and it will have to be irrigated very much oftener : so that as a fact the bulk of the kharif will not be sown at all or, if showers at the beginning of the season have led the cultivators to sow, the crops will be lost. In this case there will be a famine unless the people have adequate resources in reserve : and in any case there will be a fodder famine.

Next there is the case where the rains begin late, but once started are fairly copious. It is not possible to state from experience the latest date of rain beginning which is consistent with a moderately good kharif crop, but we know that if the rains have started by the beginning of August and are fairly copious thereafter, enough food and fodder can be grown to keep the people and cattle going until the rabi is harvested. The area sown, especially of the earliest crops, will probably fall short and the outturn generally will not be up to the standard; individual cultivators will be found who have got practically nothing, and some localities may suffer much more than others.

Next there is the case where the rains cease prematurely. The season of 1896 is a good example of this: up to the third week of August in that year the rains were normal, but from that date they ceased altogether. The earlier crops (maize for instance) ripened well enough in most places, but the later crops were generally failures. They were, however, available for fodder, and there was no fodder famine in this season though there was acute food famine over a large part of the provinces. It must, however, always be borne in mind that the drought of 1896 was the climax of a succession of misfortunes, and that its effects would in all probability have been much less serious if the previous seasons had been fairly prosperous. The experience of this season then shows that good rains up to August will not secure the kharif; experience also shows that one heavy fall of rain in September will save the crops in such seasons, though the outturn will be reduced, and there is likely to be a serious loss of the rice crop.

Next we may take the case of prolonged intervals of fine

weather. An interval of ten days without appreciable rain need hardly ever cause anxiety, and ordinarily the crops can stand a break of three weeks without serious injury: anything over this period is likely to cause loss. The effects of a break however depend largely on two circumstances: first on the amount of moisture in the soil, and secondly on the character of the wind. If the soil is at the outset very wet after a spell of heavy rain, a long break will do much less damage than if the soil were dry: while a dry wind (usually westerly) will deprive the soil of its moisture far more quickly than when there is a damp east wind or a calm. Sunshine again dries the soil more quickly than cloudy weather. These considerations make it impossible to lay down hard and fast standards of the variations in weather that are sufficient to cause injury: in addition it must be remembered that some crops suffer from drought much more than others. It will never therefore be safe to assume that no damage has resulted from a break lasting only a fortnight, nor, on the other hand, can it be assumed that serious damage has been caused by a break lasting for three weeks; the whole character of the season, and the nature of the crops, must be taken into account.

So far then we have considered abnormalities due to deficient rain. Rain may be in considerable excess without causing serious or general injury especially in the middle of the season. Excess is most injurious when occurring (1) just after sowing, (2) when the crops are flowering. In the first case the excessive moisture may cause the seed to rot or to develop weakly, and it may be necessary to resow the land: in the second case the proper formation

of the seed may be prevented and the outturn consequently reduced. In addition, low-lying land from which the water cannot escape will suffer from excess of rain, as the soil becomes waterlogged and the access of air to the roots is for the time being cut off. Particular crops too are liable to injury from excessive rainfall at critical periods of growth, as will be indicated further on.

The most serious danger to the rabi crops is that the soil may be too dry for sowing, as the result of a dry and hot September. In this case only those fields can be sown which can be irrigated; and though the cultivators will make every effort to get as large an area sown as possible, there will be a serious shortage, which cannot be made up by subsequent favourable weather. Further, some of the fields sown will get a bad start, and sowing will be delayed by the need for irrigation before ploughing. If in such a season no rain falls, these late sown crops will suffer, while the supply of labour and of water may be insufficient to keep all the crops alive.

If the ground has been sufficiently moist at seed time, and no rain falls during the cold weather, there need be no anxiety for the harvest as a whole, since the area commanded by irrigation is reasonably safe. The dry crops must in this case suffer, and may even be an entire loss in the drier soils; hence upland sandy villages will be the greatest sufferers.

The risk from excessive rain is much greater than is often recognised. Heavy rain just after the crops are sown may prevent germination entirely or partially, and involve either fresh tillage and sowing or the loss of the crops. If the rain comes after the crop is up there is to begin with the

weakening of the plants that necessarily follows when the soil is too wet to permit the free access of air to the roots; but more important than this is the fact that damp, cloudy weather gives a great impetus to the growth of certain plant diseases which are capable of causing enormous injury. The nature of these diseases will be indicated in the chapter dealing with the subject, but it may be noted here that the most destructive of them, usually known as wheat rust, will reduce the yield by one-half over enormous areas, and may even make the crop not worth harvesting. Barley and linseed suffer in the same way from various rusts, and other crops to a less extent.

The other abnormalities which may be expected during the rabi are frost and hail. Frost will occur in January, when most of the crops are young and not very liable to injury. It is most hurtful to arhar, poppy and tobacco, while gram and other crops may also suffer to some extent; but there is no record of any serious or general loss resulting. Hail may occur at any time from December to April: up to the end of February it does as a rule little damage, but in March or April, when the plants have flowered and are forming seed, great injury can be caused by the flowers and immature grains being bruised and destroyed, and by the ears being severed from the plants. Fortunately, the area affected by a hailstorm is almost always small, and within this area its effect varies enormously: one field may be seriously injured while others a few yards away may escape almost untouched.

It will be noticed that the causes of injury which we have discussed in this chapter are beyond the control of man: no method is known of regulating the rainfall or controlling

the occurrence of frost or hail.* Consequently the system of agriculture has been so developed as where possible to minimise the inevitable risks : and where this is not possible, as in the case of hail, the risks must be accepted as part of the cultivator's business.

Note to Chapter II.

The best description of the weather is to be found in *The Climates and Weather of India, Ceylon and Burma*, by H. F. Blanford (London : MacMillan). For detailed accounts of the effect of abnormal weather on agriculture, it is necessary to consult the reports of the various Famine Commissions.

CHAPTER III.

THE SOILS OF THE PROVINCES.

Introductory.

The soils of the provinces fall into two main classes depending on their origin. On the south of the Jumna most of the soils have been formed from fragments of rock brought down from the hills of Central India, and they are very different from those of the rest of the provinces, which are derived from the Himalayas. We shall consider here the latter class under the name of duab soils ; the Bundelkhand soils will be dealt with in a separate chapter.

Obvious differences in soils.

No one can fail to notice the superficial differences in the duab soils. In some places may be seen an uneven surface of loose sand which shifts under the influence of

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* A system intended to prevent hailstorms is carried out in parts of Europe, the means adopted being to fire charges of explosives, which are believed to produce sufficient disturbance in the air to prevent the formation of hail. The success of this system is still a matter of dispute : in any case it is much more likely to succeed among the narrow valleys where it originated than on open plains.

a strong wind: in others the land is a hard, bare plain of closely packed grey or brown earth. These two types are extremes, and neither is culturable at a profit under ordinary circumstances: the first is usually known as bhur with the addition of some uncomplimentary epithet (*e.g.*, *uraniya*, a word which indicates that the soil can be blown away by the wind), the second is most commonly termed usar. The ordinary cultivated soils lie between these extremes: closely allied to the bhur is the sandy cultivated land which usually bears the same name: closely allied to the usar is the inferior clay which grows only rice and is known variously as jhabar, dhankar or matiyar; and intermediate between these lies the great bulk of the cultivated land, the loam known as domat or doras.

This classification of soils, which is recognised by the cultivator in most if not all of the duab, is based on real differences in nature, and is therefore properly described as a natural classification of soils. Further on we shall have to notice another system of classification which places the fields according to their position with regard to the village site.

Materials of the soil.

As has been said in the first chapter, the bulk of the soil consists of sand, some of which exists as such, while the rest is combined with other substances. Some of these latter are, when freed from combination, valuable to plant life, others are apparently of no value, and some are actually harmful.

Among these substances is one known as alumina (containing the metal aluminium): this substance is adhesive,

and when it is present in quantity, the particles of soil stick together and give a firmer surface. All soils contain some of it, and the coherency of any particular soil depends largely on the proportion in which it is present.

Lime is another substance which is found in almost all soils. It is of great importance in cultivation, as its presence is apparently necessary for the health of the nitrate-making bacteria, while it influences the aggregation of the soil particles,* and thus affects the water supply. But the duab soils, so far as is known, everywhere contain adequate supplies of this substance.

Sand, alumina, and lime together make up prıctically the whole bulk of the soil. The other mineral substances which are essential for plant life are present in such small quantities that they do not affect the appearance of the land and can be detected only by special chemical methods, but they are essential all the same: we have already enumerated them, potash, phosphoric acid, compounds of iron, sulphur, and some substances which are not so well known. The only other mineral which requires to be mentioned is soda, a substance which we know in ordinary life in such forms as common salt and washing soda. In small quantities this substance is harmless or beneficial, but when there is anything over one part per thousand of it to the total weight of soil it is most injurious or fatal to all plant life as we see in the reh plains reh consisting essentially of soda.

To complete our account of the composition of the soil we must again mention (1) the decaying vegetable matter

* This point will be discussed further on in this chapter.

(2) the bacteria of innumerable species, and (3) the water and air which it contains.

Classification by materials.

The natural classification of the duab soils does not depend to any great extent on their composition. Great differences in the amount of lime would, it is true, make a marked distinction, but they do not apparently occur with any degree of frequency. The quantity of soda when great indicates a distinction between plain usar and reh-usar, but in the present state of our knowledge this distinction is of little practical importance, as both classes are unfit for cultivation. Alumina when present in quantity makes the soil sticky when wet and apt to crack when dry, as we see in the rice lands, but these peculiarities are not due solely to alumina but depend also to a great extent on the size of the particles of the other substances with which it is mixed. Vegetable matter is important in classifying soils by position, but not in the natural classification, while the quantity of air and water depends on other circumstances.

Formation of soils.

The natural classification in fact depends on *the average size* of the soil particles, a subject which we must consider at some little length. If we look at one of the hill streams shortly after heavy rain, we can see that the water contains a good many fragments of rock which it is gradually carrying downwards. The largest of these fragments may be stones of considerable size, while the smallest will be mere dust which can be seen only by the cloudiness it produces in the water: between these two limits fragments of all sizes will be found.

If we follow the stream to a point where its speed is checked, probably at a pool, we find further that much of the solid matter is deposited at the bottom of the pool, and that it is deposited in order of size, the largest stones at the point where the speed is first checked, the gravel a little further on, then the coarse sand : whether the finer sand and the dust are deposited depends on whether the flow of water is absolutely stopped or whether it continues at a reduced speed. We thus see that the size of the particles which can be carried by water depends on the speed : the greater the speed the larger the particles. Thus if we charge a stream of water with fragments of various sizes and then check the speed, the water will sort out the fragments and deposit them roughly in order of size. It is this sorting action of running water which is mainly accountable for the differences in the duab soils.

Let us now turn from the hill stream to the Ganges khadir somewhere in the centre of the provinces and see what happens there. We will find no stones or gravel, as the speed of the river is not great enough to carry these materials and they have all been dropped soon after the river has left the hills. But we see that the water is muddy, that is, it is still carrying solid matter ; and if we put some of the water in a bottle, this solid matter will sink to the bottom. Again, we find that the river when in flood has been depositing solid matter in different places : in one place it has covered good fields with some inches' depth of coarse, nearly white sand : in another it has left a layer of fine mud on top of sand deposited in previous years. Again, if we look at a place where the shrub known as jhau has sprung up in the sand, we can see that fine mud has been

dropped on the up-stream side of many of the plants, while there is much less or none at all on the down-stream side. All these phenomena are illustrations of the sorting action of the water. The river when in flood has carried large quantities of materials of all sizes from coarse sand to fine dust : where the flood water has spread out over a wide stretch of land, its speed has decreased and the coarser sand has been dropped (thus perhaps ruining what was fertile soil) : further on where the speed has decreased further, the finer mud has been deposited. So when water is flowing round the stems of the jhau its speed is checked at each plant and a little of the finer mud dropped there.

Now there are strong reasons to believe that what we see going on in the khadir on a comparatively small scale, went on formerly over the whole of the duab, and that in fact the land of the duab has been built up by this means ; in other words the duab was once all khadir with the rivers flowing over it. Where the flow of the water was only slightly checked, we have the bhur : where there were back-waters and pools we have the usar, and elsewhere we have the culturable soils made up of particles of intermediate size. And just as we now see sand deposited on loam and fine mud on sand, so in times past changes in the direction and speed of the flow have resulted in layers of sand above clay and clay above sand, such as we find whenever we look at an excavation in the ground. We can also understand why on the whole the soil is more sandy near the hills and more clayey further off. Of course there is clay in the Meerut division and sand in Benares, but, on the whole, the south-eastern soils are heavier than the north-western, since *most*

of the larger particles tend to be deposited at the places where speed is first checked.

Recognition of different soils.

The difference between the three main classes, sand, clay, and loam, can usually be recognised by the eye. A further simple test is to moisten a pinch of soil and rub it between the finger and thumb. Where the particles are very fine (that is, where the soil is clay), a slimy mud is produced with little or no grit : where the soil is coarse sand, there is no slimy feeling, but the grit can be distinguished at once.

Water contained in the soil.

The reason why the size of the particles makes such a difference that the people have taken it as the basis of their classification is to be found in the behaviour of water in the soil. We have seen that the particles of soil are usually surrounded by a thin film of water, from which plants derive both their moisture and their stock of plant food. Now the amount of water held as a film will depend on the surface area of the particle ; and the smaller the particles the greater the surface area in a given quantity of soil. For instance, a cube of six inches has six faces, each of 36 square inches : its total surface area is therefore 216 square inches. If the cube is cut into two equal halves, the surface of each half is 144 square inches, so that the total surface in the space occupied becomes 288 square inches ; and the more the cube is subdivided the greater becomes the total surface area ; that is, the smaller the particles the greater the surface area, or the smaller the particles the greater the amount of water which will be held by a given quantity of soil.

Downward movement of water.

Secondly, the smaller particles will pack more closely together than the larger, that is, the air spaces between them though more numerous will be individually smaller. Now the movement of water in the soil, both upward and downward, is controlled by the size of these spaces. Consider first the downward movement (that is, drainage). If water is poured on a layer of coarse sand, most of it passes at once through the spaces between the particles and runs away downwards : if the sand is replaced by fine clay, very little water passes through, but most remains on the surface. With loam, some of the water will gradually drain away, but it will not run straight through as in the case of sand. This then is one practical distinction : speaking roughly, water passes freely through sand but not through clay.

Capillary movement of water.

But the downward course of water, though the most obvious, is not the only direction in which it moves. If you wet the bottom of a lump of sugar, the whole lump gradually becomes moist, that is to say, the water has travelled upwards through the lump. Now it has been ascertained by experiment that this form of motion (which you will read of under the name of capillary movement) depends on the narrowness of the spaces separating the particles in the lump of sugar or other substance under consideration : the narrower the spaces, the quicker is the rate of flow, at least so long as the spaces are wide enough to allow of any movement. This capillary movement may go on in any direction, and it takes place in such a way that the distribution of the water in the lump tends to equality. If then

we have the surface soil dry and the sub-soil wet, water will constantly pass upwards from the wet layer to the dry until the amount of water in the two layers is more or less equal. But the speed at which the water travels depends on the average size of the particles. In coarse sand the pace will be slow, so slow indeed that when the wet layers lie a long distance below the surface the movement of water will practically cease. In the finest clays too the movement will be comparatively slow, as the spaces are so narrow that obstruction results. In the loams the movement will be quicker, and among them the speed will be greatest where the particles are finest.

Loss of water from the surface.

The practical importance of this upward movement of water is very great. In ordinary soils the surface is drier than the subsoil throughout practically the whole cold weather and also through a great part of the rainy season: any one can satisfy himself of this fact by digging holes in cultivated land. The reason why the surface is drier is that the water on the surface particles tends to pass away into the air at any time when rain is not actually falling. The rate at which this process (known as evaporation) goes on depends partly on the temperature and partly on the amount of water already contained in the air, so that other things being equal, the hotter and drier the air, the more quickly does the surface soil lose its water. If then the surface soil could not obtain water from below it would soon become so dry that plants could not obtain water from it, and the growth of crops would be impossible. As a matter of fact

we see that in a drought it is the crops on coarse sand which wither first, and those on fine loam which last longest: the former get little or no water from the deeper soil levels, while the latter have a steady and fairly rapid supply.

Again, water leaves the soil not only from the surface but, as we have already seen, through the plants growing on it; a heavy crop will extract from the soil an enormous weight of water, nearly all of which passes into the air. This water is drawn from the soil immediately surrounding the roots, which are usually near the surface; and if there were no upward movement of water the soil in contact with the roots could not provide enough water for the needs of the crop. As a matter of fact the water drawn up by the roots is replaced by water from above if the surface is wet, and from below if the surface is dry.

Regulation of the movements of water so as to benefit plants.

Thus in the ordinary condition of the soil water is travelling upwards and escaping either at the surface or through the plants: and except where water is in excess the cultivator obviously wants as little as possible to leave the surface, which does him no good, and as much as possible to pass through the plants, which it helps to nourish on its way. Now the process of evaporation is not beyond the control of the cultivator; indeed it is just in this matter that the skill of our best cultivators is most marked. He cannot of course control the amount of water in the air: he can however, to some extent, control the temperature of the surface soil. The soil derives its heat from the sun, and if some of that heat is kept off the soil will be kept

comparatively cool and will lose less water than would otherwise be the case. This shading of the soil is done by keeping it covered with crops: the commonest device is the growth of low spreading crops in between high crops where the plants are wide apart; thus gourds are grown in maize fields, and urd and other pulses in juar fields, and so on. Further, the amount of water lost from the surface of a field depends on the state of the surface: when the land is beaten down into a crust water escapes very quickly, while the escape is much slower when there is a layer of loose soil on top. The reason for this difference is to be found in the laws which have been discovered regarding capillary movement, laws which we cannot discuss in this book. In practice the rate of evaporation can be reduced by loosening the surface with a plough or hoe; it can be increased by rolling the surface or flattening it by drawing any heavy object over it. In the next chapter we shall see the manifold ways in which the cultivator takes advantage of this principle.

Behaviour of different soils with respect to water.

We have now seen the fundamental distinction between the different soils: clays hinder the downward passage of water, and to some extent retard its upward movement: they will sometimes be too wet, and sometimes too dry: sand lets water escape downwards too easily and does not let it come up at sufficient speed; it will often be too dry, rarely too wet (unless there is clay below, an important

exception, which we will notice in detail in the chapter on drainage). Finally in loam the movement of water both upward and downward is regulated to the best advantage.

Formation of reh.

As we have just been considering the question of evaporation, it will be convenient here to notice the fate of the soda which as we have seen exists in the duab soils and which in quantity is fatal to all cultivation. Soda behaves in the soil like potash (*vide* Chapter I). Most of it is in the form of insoluble compounds, which gradually weather and give up the soda in a simpler state. Where there is a downward movement of water, that is, during and after rain in sand and loam, the soluble soda is washed out of the soil and escapes into the drainage water, ultimately reaching the sea, where most of it is found in the form of salt. Hence in all properly drained soils the free soda is not accumulated to a dangerous extent. In the stiffest clays, however, where there is practically no downward movement of water, the soda cannot be washed out of the soil by this means: consequently in the dry season the whole accumulation moves steadily upwards with the water in which it is dissolved. Soda cannot, however, like water pass away into the air, so that, when evaporation takes place, it remains at the surface and appears as a white crust on the soil. This crust is dissolved again as soon as the surface is wet, and is carried down into the soil so far as the water penetrates, but is not washed out, and is ready to rise again as soon as the surface dries. The problem of utilising land of this sort is too complex to be discussed here.

Loss of plant food by drainage.

The question will naturally be raised why loam and sand, which readily lose their soda by drainage, do not also lose the potash and phosphoric acid, which are also soluble in water. As a matter of fact such loss does not occur to a material extent, because the substances tend to become insoluble in the conditions which then prevail, but the processes which take place cannot be explained here. The fact remains that while the injurious soda is rapidly lost, potash and phosphoric acid remain in the soil : nitrates, on the other hand, are lost almost as readily as soda, but it will be remembered that they are produced by bacteria and used up almost as rapidly as they are formed : probably therefore they do not lie in the soil long enough to be lost in great quantities, but the extent of the loss has not yet been ascertained in these provinces.

Summary of the effects of water in soils.

It will perhaps be well if we recall at this point the principal ways in which the soil water is important to the crops. An adequate supply is needed by the plant for its growth, and also to carry the nitrates and the mineral plant food, while a certain degree of moisture is essential for the efficient work of the soil bacteria. Too much water, however, prevents the bacteria from acting, and at the same time cuts off the air supply ftom the roots. Thus, on the whole the regulation of the supply of soil water is the greatest necessity of all, once the plants have started to grow, and consequently there is every reason to base the classification of soils on their behaviour in this respect. At germination, however, water fulfils yet another function. We have seen

that successful germination depends on the moisture and the temperature of the soil: but the temperature itself depends to some extent on the moisture, since the process of evaporation reduces the temperature. We make use of this principle when we cool our houses by a thermantidote: we force the air to take up moisture, knowing that it will be cooled in doing so. In the same way if a field is too hot for sowing (as is usually the case in mid October) it can be cooled by hastening evaporation, which, as we have seen, can be effected by rolling the land. It is not, on the other hand, practicable artificially to warm land which is too cold for sowing, but the question seldom or never arises in the duab, as the sun can usually be trusted to bring the soil to a sufficient temperature.

Improvement of soils in respect to water.

Now seeing the extent to which the value of land depends on the average size of the particles, we may consider what can be done to improve land which is defective in this respect. The first obvious suggestion is to mix soils, to put clay on the bhur and sand on the usar. Unfortunately this process is usually so expensive that it cannot be carried out profitably. For instance, to put a layer of sand one inch deep on usar will require over 120 cartloads of sand to the acre, and sand is usually not to be had close to the usar, so that the expense of sanding becomes very heavy, while we know by experience that a dressing of so little as one inch of sand makes very little difference. Apparently claying sand is more likely to be profitable, as a little clay has more effect on sand than a little sand on clay; the process has in the past been extensively carried out in England, and I have

heard of a few persons in Oudh who have tried it on a small scale, but it is not in general use. Perhaps the Oudh practice of scattering the clods dug from tanks on the fields has some effect in this way, though its principal benefit appears to be in the fact that these clods contain a certain amount of organic matter derived from the water of the tank. However, broadly speaking, we may say that the process of mixing soils is not carried on in these provinces, and that its cost will probably continue to stand in the way of its adoption in most cases. Another possible course is to alter the size of the particles already present: we cannot in practice break up those which are too large, but there is a means of making small particles adhere together and form larger complex particles, thus opening the texture of a lay. This is done by means of chalk or, better, quick-lime: if you shake up a little usar soil in a glass with water you will get a turbid brown liquid which does not clear rapidly on being allowed to stand; if to this you add a little lime, the liquid clears almost at once and the solid matter settles in the glass, not in a slime but in small lumps. Clays are regularly limed in England and other countries in order to open them up in this way by forming larger particles, and the same treatment is apparently effective on some of the heavier clays in these provinces; but here again the question of cost is serious: we need perhaps ten tons of lime to the acre, and the cost of this may approach, if it does not exceed, the price that the land would be worth if entirely reclaimed.

Another method of improving defective texture is to add organic matter to the soil; but it will be more convenient to postpone this subject till we have considered the alterna-

tive system of soil classification, which depends on the amount of organic matter.

Natural classification of soils.

We may now sum up the characters of the natural soils as follows :—

Clay.—The particles are very fine and readily cohere. The soil forms compact masses : it will absorb a large quantity of water, but will not allow any great quantity to pass through. When wet it forms a slimy mud. When dried its surface is cut by cracks, owing to its bulk shrinking in consequence of the loss of water. When the soil contains considerable quantities of soda, the surface will in dry weather be covered wtth a white crust.

Sand.—The particles are large and do not adhere together, so that the soil is loose. It will absorb less water than the same bulk of clay, but will allow water to pass freely through it, and will dry very rapidly. It will not form mud when wet or crack when dried, nor will it have a crust of reh.

Loam.—All soils intermediate between clay and sand are called loams.

It is obvious that these classes are not entirely distinct : it is impossible to lay down a definite distinction between the lighter clays and the heavier loams, or between the lighter loams and the firmer sands, so that questions regarding the class of particular fields will often cause difficulties. Classification is therefore a matter requiring judgment, and differences of opinion must be expected. For practical purposes the important point is that the classification should be as uniform as possible over the area under consideration : thus a settlement officer working in a defined area is con-

cerned to see that what is classed as loam in one village is not classed as sand in another: but it does not much matter if the line between loam and sand or between loam and clay is drawn differently in different districts. What is important is to remember that the classification may and does vary in detail from district to district, though its general scheme may be uniform. Again we often meet with subdivisions of these main classes, first and second class clay for instance: these subdivisions are made with the object of facilitating a settlement officer's work, and the line dividing them is almost always a matter of convenience.

When therefore an officer comes to revenue work in a new district, his first business is not to apply some scheme of soil-classification which he has learnt elsewhere but to understand the scheme actually recognised in his district. He will find the outlines similar, but the distinctions drawn at different points; in particular, he will probably find that the general character of the locality has influenced the point of division: thus soil will be classed as loam in a sandy district which would be called sand where clay was predominant.

Another point of practical importance in classifying the natural soils is to distinguish culturable land from barren. The question arises at both ends of the scale. There is no doubt that clays containing much soda are not culturable by the means at the cultivator's disposal, while the very stiff clays though not contaminated by soda cannot be tilled effectively. On the other hand, the lighter clays are perhaps the most fertile soils of all. Where to draw the line between these extremes is a question that can be decided only by practical experience. Much depends on

the density of the agricultural population ; where the density is great and there is not enough good land for all, the inferior soils will necessarily come under cultivation. The resources of the cultivators are also factors to be considered : strong cattle can till land which would be worthless with weaker animals. The prevailing prices of produce are also important. Similarly with sandy land, the density of population and the value of produce contribute largely to determine the point up to which sand will be cultivated, but in both cases the facts of any locality can be ascertained only by study on the spot.

Classification of soils by position, i.e., by amount of organic matter.

We must now turn to the alternative system of classifying cultivated land according to its position with regard to the village site, the so-called classification of artificial soils. The basis of this classification is the amount of organic matter present in or supplied to the soil. It is obvious that under existing social conditions the fields immediately adjoining a group of houses will receive most of the refuse that is thrown away by the inhabitants and most of their excrement. These supplies of organic matter are an important feature in all cases : in addition, the practice over the greater part of the provinces is to apply the available manure to the fields nearest the site, thus avoiding the expense of carrying it to the outlying land. Thus the fields nearest the site are most often manured : fields lying a little further off are manured occasionally, and those at the greatest distance get no manure at all. The result is obvious to the eye when the crops are on the ground : each group of houses is a centre

from which the fertility gradually decreases to the outskirts of the land depending on the village or hamlet. The most remunerative crops are found near the houses and the inferior crops further off.

The highly manured land round the houses is known variously as goind, gauhan or bara : the outlying unmanured land as palo, uparhar, or by other names : the intermediate zone usually as manjhar. Obviously the point at which one class passes into another will in this case also be a matter of opinion, and the remarks made above as to the natural classification will apply with at least equal force. In some cases the classification has been simplified by the omission of the middle zone, so that only two classes are kept, the homeland and the outlying land.

The character of the gauhan or homeland will depend first on its natural features, that is, on the nature and size of the mineral particles; the greater quantity of organic matter will however enable it to hold more water than it otherwise would, since organic matter can absorb large quantities of water. Secondly, the larger supply of organic matter will support increased numbers of the small living beings which form nitrates, and the supply of nitrates will be more rapidly increased. Thirdly, the manures applied will incidentally return to the soil in an available form some of the mineral plant food which has been removed from it by previous crops. The distinguishing feature of the homeland is however its wealth in nitrates either ready made or in process of formation, and, on the other hand, the outlying land is usually marked by its poverty in this form of plant food. In practical revenue work it is however most important to remember that the fertility of the homeland is

largely controlled by its original character. Where a group of houses has been built on heavy clay the fields round them will never be so good as if the land had been loam; the defect of the clay (obstructed drainage) remains almost untouched. Sandy land, on the other hand, benefits enormously by proximity to houses since the addition of organic matter tends to remedy the rapid loss of water which is its most obvious defect. In some districts where the classification of soils is very detailed account is taken of these facts, and the gauhan is divided into gauhan-dumat, gauhan-bhur, etc.; elsewhere the same facts are recognised by dividing the gauhan into two classes, superior and inferior.

It is interesting to notice that the distinction between homeland and outlying land decreases in the provinces from East to West. No one could fail to notice it in (say) Jaunpur or Partabgarh, while the crops are on the ground; while in Bulandshahr or Meerut the distinction is often imperceptible. The reason of this is that the practice of cultivators differs: the western cultivators, especially the Jats, are accustomed to manure all their land, home and outlying, in turn, so that no portion is specially favoured. The homelands therefore may not give so good a yield as further East, but that of the outlying lands is much superior. Probably on the whole the western system gives a greater yield of produce from a given area, but it does not follow that it would be more economical for the eastern cultivator to adopt it. The Jat cultivator can usually spare cattle to cart the manure to a distance: the eastern cultivator cannot do so, and the cost of carrying it in head-loads may be prohibitive. This point, the economy of the labour available, will need our attention further on: it is mentioned here merely as fur-

nishing a partial explanation why the soil classification in the West must frequently proceed on different lines from those found most suitable in the East.

For the sake of simplicity we have spoken of the system of manuring as altering from East to West; but the same change is noticeable to some extent as one goes from South to North (Bundelkhand being of course left out of account). In this case too the change is probably due in part to the larger stock of cattle which can be maintained in the more northerly and damper districts.

Increasing the organic matter of soils.

Obviously the amount of organic matter present in the soil—being the result of man's efforts—can be altered by man: that is to say, if you treat outlying land with heavy dressings of manure such as are given to the homelands, it will gradually approach the homelands in fertility. And indeed this process can be seen at work in places where the refuse of a large community is trenched in the soil far away from houses; the resulting soil is of the highest fertility. But in the country the amount of organic refuse is not so large as to render this course practicable, and if it is desired to improve land in this way the organic matter must be prepared specially. The usual course in other countries is to grow some cheap crop on the land to be improved and leave the whole crop on the land, ploughing it in, so as to bury it in the soil. If a leguminous crop is used, the soil will in this way receive all the combined nitrogen which the crop has obtained from the air, as well as all the matter manufactured by the plant from water and carbonic acid; and in any case the latter products will be added to the soil.

As a matter of fact this process is almost unknown in these provinces; a man with a small holding cannot often spare the land for a season, as he needs the whole produce of his holding to support his family for the year; while the cost of seed, small though it seems, is an important matter to the small cultivator. Further, the process of ploughing in requires some judgment in order to secure that the crop shall be put under the soil in condition favourable for the work of the proper bacteria: otherwise, as will be understood from what has been said above, the combined nitrogen may pass either into the air or into the drainage and be lost. The experimental ploughing in of green crops on fairly fertile soil at Cawnpore has not given very satisfactory results in practice, and it seems that this method of increasing the organic matter of the soil should be valuable rather for the improvement of the poorest soils than for raising the fertility of soils that are already fairly good. In this way ploughing in may be expected to benefit both the heavy clays and the light sands: the former will be to a certain extent opened up, while the latter will be made more cohesive and able to retain a larger quantity of water. We are not however yet in a position to lay down definite instructions for the improvement of such soils by ploughing in; much preliminary study is needed, both of the crops to be used and the method of their cultivation, in order to devise a practicable method of improvement.

Note to Chapter III.

An excellent account of soils will be found in *The Soil*, by A. D. Hall (London, John Murray), dnd also in *Lectures on the Physical Properties of Soils*. by Professor Warrington (Oxford, Clarendon Press). For detailed descriptions of the soils in the provinces, the various Settlement Reports must be consulted.

CHAPTER IV.

DRAINAGE.

Introductory.

We have seen in the last chapter that the passage of water through the soil is controlled mainly by the size of the soil particles ; we have now to enquire what happens to the water that passes through the soil. If you look at a freshly dug well, or a deep excavation of any kind, you will see that the constitution of the soil is not uniform : it consists of layers of varying thickness. Under a loam, for instance, you may find a layer of sand a foot thick, below that three feet of heavy clay, below that sand, and so on. The drainage of the surface soil depends largely on the nature of the under layers. Thus in the case we have suggested, the water that passes through the loam will run into the sand but will not penetrate the clay below it ; after heavy rain then a great part of this sand may be waterlogged, while the surface loam is not wetter than is necessary. If therefore the water in the sand cannot escape, it remains as a reservoir from which the loam can draw water to replace what is evaporated. As a matter of fact, water can in such cases usually escape though not very rapidly : the surface of the underlying clay is ordinarily somewhat sloped and the water will gradually travel down the slope. Now if we suppose that at a little distance a ravine has cut through this layer of clay, the water flowing on the clay will appear on the side of the ravine and will flow down to the bottom. If we look at a ravine some time after heavy rain we can often see the water oozing out from just above one or more layers of clay. So much of this water as is not evaporated flows down the

ravine till it reaches a river, and thence goes on to the sea. Of course this water carries with it the injurious soda salts which it has dissolved in passing through the loam : the ultimate destination of these is the sea. But the sea is constantly losing fresh water by evaporation while the soda salts remain in it : it is therefore gradually getting salter, and in fact we may assume that its saltness is due mainly to this steady accumulation of what has been washed into it from the soil.

This then is an instance of drainage of the simplest kind. Where the clay bed is not cut by a ravine, the water continues to pass over it, and possilby it may come to flow under a second clay bed : there we get a layer of saturated sand between two layers of clay. Further on the original layer of clay may get thinner and thinner till at last it disappears and the layer of sand unites with another that lay below it. Experience gained in sinking wells shows that the surface soil rests on successive layers of sand and clay, and that these layers are often not continuous over a large area : a bed of sand may be entirely enclosed by clay or a bed of clay by sand.

Unless the sand is entirely enclosed by clay, it will usually at some point touch on a ravine or river bank, and water will drain out of it at this point in the manner described above : while a bed of sand so enclosed by clay that any flow downwards is prevented can lose its water only by evaporation upwards through the surface soil. Thus all the water that passes through the soil is accounted for : but much of the rainfall flows over the surface of the stiffer soils till it either enters a ravine or collects in a natural depression, or what we know as a jhil.

Flow of water through sand.

It is important to know that water does not flow through sand as quickly as it flows over a smooth clay surface: much time is lost in passing through the sand, and the flow is thereby retarded; the coarser the sand and the greater the slope, the quicker is the flow. Natural drainage is therefore a slow process, and sand may remain saturated for a considerable time if the water has to travel for a long distance through it. We may also note that, though for simplicity we have considered the clay as impervious, many clays will let some water pass downwards through them, though the amount is very small compared to that which passes through sand.

Effect of natural drainage on cultivation.

It will be seen from this description that the value of most surface soils for cultivation will depend greatly on the nature of the underlying layers. Thus a coarse sandy soil lying immediately over a heavy clay will get waterlogged very quickly, while it will dry up in a very short time: the crops on a soil of this kind will therefore suffer greatly in wet and dry seasons alike. This appears to be the case with much of the bhur land of Rohilkhand. On the other hand, a clay soil, if the surface layer is at all thick, may be almost independent of the nature of the underlying layers, as so little water can penetrate through to them: this remark applies to many usar soils which consist of a solid block of clay several feet thick. On the whole, the soils which suffer most from want of natural drainage may be divided into three classes: (1) the heavy clays, (2) the light soils underlaid by heavy clays, and (3) the lower parts of natural

depressions. We may now proceed to consider what measures can be taken to remedy these defects.

Methods of artificial drainage.

Artificial drainage can be carried out either by surface cuts, leading to a ravine or river, or by underground channels or by drainage wells. A drainage well consists of a hole pierced through a clay stratum so that water can flow through to the sand below it. These wells are not in use to any extent in these provinces, and we may pass over the details of their construction. Underground channels, which have usually to be lined with earthenware pipes to prevent their choking, are common in many countries ; but they involve a considerahle capital outlay, and are not used in these provinces, so we may pass over them also. Open drainage cuts, on the other hand, are common features of all canal districts : they are simply channels dug from the place which needs drainage to the nearest ravine, and their construction is simple ; their alignment on the other hand usually requires accurate surveying and trained judgment, and wherever possible an experienced engineer should be employed to carry out the work.

Drainage of clays.

Now of the three classes of land requiring drainage, the heavy clays cannot apparently be drained effectively by surface channels : such channels receive water from the surface but they do not to any extent provoke a flow of water *through the clay*, which, as we have seen, is essential to wash out the injurious soda compounds and keep the land aerated. Underground channels have been tried on such lands, but so

far without success, as the fine particles of clay get into the pipes and choke them. The expense too is so great that it is very doubtful whether such drains would ever pay. Drainage wells have been tried, so far without success, so that the problem of draining these soils is still unsolved.

Drainage of light soils.

The second class, light soils resting on heavy clays, could apparently be treated by drainage wells, but this has not been tried: open channels are usually cheaper. The question of draining such soils is however complicated by the fact already pointed out, that they dry very quickly. The more you drain them the more they will suffer in drought, and as irrigation of such soils is expensive and unsatisfactory, drainage may do more harm than good. What is usually required in such cases is merely to keep open the natural drainage lines, rarely to supplement them by artificial cuts. We usually find natural drainage lines running through the bhur tracts : they may be well-defined streams with a regular though sluggish flow, or they may be found as a line of jhils separated by barriers of sand. As long as they are flowing they show that drainage is proceeding, and to increase the rate of flow may do more harm than good, or at least it should never be undertaken without careful expert examination of the particular locality. Where however there is no regular flow, and the people complain of over-saturation, it is usually desirable to cut through the barriers obstructing the stream and enable the water to flow away; not so much as to empty the jhils rapidly, but just enough to maintain a slow current. The barriers which separate the jhils are formed naturally in streams that flow near sand.

If you look at a place where water has flowed into such a stream you will see that it has left a more or less fan-shaped heap of sand at the point where it has entered the current : the reason of this is, as we have seen, that the amount of sand which can be carried by flowing water depends on the rate of flow : the speed of the water is checked where it meets the stream and the sand is deposited. As time goes on bars of sand will be formed across the stream, damming it up : and thus the flow of the stream is reduced, and it in turn drops some of the sand which it carries. If a heavy flood comes down such a stream it may tear these bars away : otherwise the stream may be gradually cut up into jhils, and the water from the underground sand can no longer escape : the country will therefore get more and more waterlogged. By cutting a channel through the barriers, we only restore a stream which has been accidentally interrupted.

It follows that the prosperity of these sandy tracts depends to a large extent on regular attention to their drainage lines. But what is everybody's business is nobody's business, and individual landholders do not as a rule keep their drainage lines in order : besides, one negligent landholder can obstruct a whole channel. Such drainage channels therefore demand the care of the authorities.

Drainage of natural depressions.

The third case of obstructed drainage, natural depressions in the surface, is usually dealt with by open drains, which can be cut through the higher ground surrounding the depression and on to the nearest stream or ravine. The questions whether it is desirable to drain a particular depression, and

if so to what depth, are exceedingly difficult to decide, and no general rules can be framed for dealing with them: each case must be decided on its merits. The problem usually presents itself somewhat in the following form: we have a shallow depression with gently sloping sides; the higher parts of the slopes are fairly good loam and are irrigated when necessary from the water contained in the depression; below this there is heavier soil usually fit for rice and also irrigated in the kharif when necessary; below this again there is the stiff clay bottom on which the water lodges. Now in a year of very heavy rainfall, the depression may almost fill up with water; the rice may be entirely lost and the kharif in the loam higher up seriously injured: further it may be impossible to take even a rabi crop off the rice fields, as they do not dry up enough for cultivation. Thus in a very wet year much of the land is wholly useless, but there is an ample supply of water for the rabi irrigation of the higher fields. In a dry year, on the other hand, the kharif will probably be good, but there will be little or no water for the rabi irrigation: indeed, there may not be enough even to keep the rice alive at the end of the kharif. If a drain is cut so that the surplus water can flow away, the evils incident to a wet year are avoided, but those of a dry year are intensified, as water has drained out that would have been invaluable later on. Whether such a drain is on the whole a benefit or an evil depends on the local circumstances. If wells can be made easily and cheaply on the higher parts of the slopes, so as to protect these in dry seasons, the drain is usually a great advantage; so it is if the lower parts of the slopes are agriculturally of much greater value than the higher parts. On the other hand, if

the higher parts are the more valuable (they are nearly always from the nature of the case more extensive), or if they cannot be otherwise irrigated, the drain may become a great evil.

If a landholder or an officer has to decide whether a drain should be made in such circumstances, his only safe course is to hear the views of all the cultivators who would be affected by it and estimate as far as he can the relative advantages over a series of years. He will of course allow for the fact that cultivators all of whose land is on a high level will bitterly oppose a drain which may be demanded as a necessity by those who hold only on the lower slopes. If the balance of advantages is in favour of the drain, he may have to satisfy individuals by a small reduction of rent or by giving them a bit of land in a better position, while he can (subject to the rent law) test the desire for the drain by ascertaining whether those who demand it are willing to pay a small enhancement.

The level to which the drain is to be dug must be decided partly on engineering and partly on agricultural grounds. It may, for instance, be found that to dig a drain to the depth that would give the greatest advantage would involve an excessive amount of earthwork, while a drain a few feet shallower could be constructed at a very much smaller cost and do nearly as much good. Or the more efficient drain might have to pass through land belonging to some one else who would object to its construction, while the alternative might lie entirely in the village. All these questions have to be gone into thoroughly before a drainage proposal can be fully dealt with.

Cases may occasionally be found where a large tract of country contains many land-locked depressions and could be benefited naturally by a large main drain into which the depressions could discharge their surplus water. Cases of this kind have been successfully dealt with in tracts where the introduction of a canal has necessitated Government interference: outside the canal tracts such projects cannot be carried out without great difficulty, as it is impossible to secure unanimity among a large body of landholders, and no satisfactory means have yet been devised for distributing the cost among those who will derive benefit from the work: in many cases too the discussion of such a project may produce so much ill-feeling among neighbours that any good it might do is more than counterbalanced.

CHAPTER V.

TILLAGE.

Implements and their use.

We have seen in the first chapter that the method of tillage affects almost all the conditions of plant growth which the cultivator can control. We have now to enquire how these operations are carried out. The cultivator uses ordinarily four implements: the plough, the clod-crusher, the spade, and the hoe. The plough is a wedge-shaped block of hard wood with an iron sole: it has a handle by which it is guided, and a beam projecting in front by which it is drawn. When the plough is drawn through the ground the point of the wedge cuts a furrow and the body of the wedge presses the soil at the side into the space left by the last furrow, but does not to any great extent invert the soil:

the soil is thus stirred up and, if it has been packed together, broken into smaller pieces. The art of using this plough consists first in using it at the right time and secondly in working it evenly. If the ground is wet and muddy it is useless to plough, as the soil does not get broken up : while if the ground is hard and dry the plough cannot be worked properly by bullocks, but merely makes a scratch on the surface of the soil. The ground must, therefore, be neither too wet nor too dry : but only practical experience can enable a man to judge whether land is fit for ploughing or not. Much depends on the consistency of the soil: a light sandy loam can be ploughed when to plough a clay would be a waste of labour, or would even do harm by working the surface into regular mud. As regards the working of the plough it is important to get an even depth so that the whole field may be tilled uniformly ; the depth usually attained may vary from three to five inches according to the size of the plough, which in its turn depends largely on the strength of the cattle available : thus the rich cultivators of the western districts, who can afford and are accustomed to use powerful cattle, have their ploughs made larger and heavier than those of the east. Again, it is important that the furrows should be straight and at a proper distance apart : if they are crooked, or too far apart, spaces of untilled land will be left between them, and the field will be patchy. The regulation of the plough's course is effected by pressure on the handle, and its management can be learnt only by practice.

The clod-crusher is merely a flat log of wood which is drawn over the field by bullocks, the driver standing on it. It breaks many of the clods left by the plough and also

smoothes off the ridges, so that a level surface is left. In some of the western districts a roller of wood or even stone is occasionally used instead of a flat log. The spade (phaora) is used mostly for odd jobs such as mending or cutting a field boundary, digging a corner left by the plough, &c., but an important use is for tilling land intended for valuable crops which require a deep soil. A whole field is then dug over by the spade to a depth of ten inches or a foot, that is much deeper than the plough can reach: again the fields bearing a crop of young sugarcane are often dug between the plants with a narrow form of spade or a broad pickaxe. The spade is also used for breaking up new land; for instance when a piece of heavy clay in the khadir is to be brought under cultivation, it is sometimes so firm and so full of roots that a plough cannot be worked; if so, it is dug with a spade and allowed to weather, after which the plough can be used. The spade is also used for tillage by persons who have only a small field or two of land and cannot afford to keep bullocks. Finally the hoe (khurpi) is a small iron blade fixed in a handle which can be used for an immense variety of purposes: its principal use in tillage is to remove weeds and to loosen the surface soil round young plants.

Kharif tillage of an ordinary field.

The methods by which the cultivator uses these simple instruments to produce a most effective result can best be explained by describing the treatment of a field intended for one of the staple crops: the special treatment required by individual crops will be noticed when we come to deal with them in detail. First then we will take a kharif crop

such as maize. The field has probably been under a rabi crop cleared away in April: its surface soil is dry and more or less compact, and it cannot be ploughed to advantage until rain falls. If a storm comes in the end of May or early in June, the field will be ploughed roughly. This breaks up the surface, and admits air into the soil, thus probably facilitating the formation of nitrates, but the immediate object is to make the field ready to retain the next rain. When heavy rain falls on a dry and compact field, much of it flows off the surface, bearing with it some of the surface particles of soil (which presumably contain plant food in a soluble condition): thus both water and plant food are lost. When, however, the land has been ploughed, the roughness of the surface prevents the rain from flowing away and nearly all of it soaks into the ground. Thus an early ploughing secures that the soil shall get thoroughly wet sooner than would otherwise be the case. When the rain has come in earnest, ploughing will be resumed as soon as the surface has dried sufficiently: usually at least two more ploughings will be given, but the exact number will depend on many factors: the work to be done, the ploughs and cattle available, the weather, etc., etc. The cultivator will aim at having the soil as thoroughly stirred and broken up as possible in the time and with the means at his disposal: and he will sometimes cross-plough, that is, plough first along and then across the field to secure this object: he will then sow his seed. When the seed comes up the young plants will not be alone in the field: the seeds of innumerable weeds, which are always in the soil, will germinate in the conditions which suit the seed sown and if these are allowed to grow the

land will be overcrowded : the next operation therefore is to remove the weeds before they injure the plants. This is done by scraping the surface of the field with the hoe ; the weeds are thus either uprooted or severed from their roots, and soon wither : they are gathered into heaps on the boundary and usually left to rot. (Some weeds are suitable for human or animal food, and these of course are used and not thrown away). The surface soil, which has probably packed under the influence of rain, is loosened by the hoe in removing the weeds : this is an important benefit as the loss of water by evaporation goes on much more rapidly from a packed smooth surface than when the surface soil is loose ; and even in the rains the cultivator has to think of saving the moisture in the soil, for the heat of the sun is so strong that the surface soil dries very rapidly, and the luxuriant crops grown at this season consume immense quantities of water. In some seasons, and with some crops, it may be necessary to hoe the soil once more, in order to save the moisture : this will happen when the soil has again been compacted and rain holds off : another hoeing will then be of service in the same way. It should be noticed that this process is not required when once the plants have grown so large as to shade nearly all the ground, as the shade will minimise evaporation. Other occasional operations may be necessary during the kharif : it may be necessary to drain off water that has lodged on a low-lying spot, or to bank up earth round plants (*e.g.*, maize) that get top-heavy as they grow : but the main process is over when the cultivator has thoroughly broken up the soil before sowing, has removed

the weeds and has loosened the surface soil to the extent that may be necessary to keep the field thoroughly moist.

Rabi tillage of an ordinary field.

Tillage for the rabi will usually begin in August as soon as the kharif crops have received attention : if, however, the land has been bare since the last kharif, one ploughing will have been given in the cold weather provided enough rain has fallen to make this possible. This by breaking up the soil will facilitate the disintegration of some of its particles into soluble forms, and also the manufacture of nitrates. From August to September the land will be ploughed as often as can be managed, having regard to the weather and the urgency of other work. In this way the cultivator will by the middle of October have the fields intended for wheat and other good crops thoroughly pulverised and in excellent condition for sowing. The after-tillage in the cold weather depends largely on the irrigation : if it is found desirable to irrigate early while the plants are very small and much of the ground bare, the irrigation will perhaps be followed by hoeing to keep in the moisture : but if the first irrigation is delayed until the ground is well covered, hoeing will be unnecessary as the ground is shaded, and might be injurious to the thick-growing plants. No further tillage is then required.

In both seasons then tillage is, on paper, a simple thing requiring only that the soil should be pulverised as completely as the time and the cultivator's resources will allow, and that the surface of the land should be kept loose while the crop is young ; but practical experience is quite essential

not only to do the work thoroughly but to know when it should be done. The result of tillage as carried out by an expert cultivator is to produce a layer of loose, finely pulverised soil four or five inches deep on top of the unaltered soil : this layer is ample for a seed-bed in which the seeds can germinate and the young roots make a start ; later on they have to grow through the untilled soil lying below. This loose layer of soil dries rapidly, but as has been said above it serves as a protection to the moisture in the soil lying below, which is the source from which the plants must derive most of their water as soon as their roots have developed to any extent.

Depth of tillage.

The want of depth in tillage is an objection frequently urged against this system of cultivation. Now the cultivator knows that in certain circumstances a deeply tilled soil is an advantage, and as we have seen he often digs a field with the spade when growing crops such as potatoes or vegetables which will pay for the cost. But the time occupied and the cost incurred in digging make it impossible that any large proportion of the land of the duab can be cultivated in this way, and the cattle of the country are not as a rule strong enough to draw a plough deeper through the soil. It must be remembered too that in deep cultivation a greater quantity of soil is almost necessarily exposed for a time to the direct sunlight : evaporation is therefore increased and more of the stock of moisture is lost : it seems probable then that deeper tillage would not be an advantage where land cannot be irrigated, or when an extra irrigation before sowing would

be rendered necessary to compensate for this extra evaporation. Enough is not known of the habits of the nitrate-making micro-organisms in this country to say whether the production of nitrates would be much increased by moderately deep tillage, so that the only certain benefit is the disintegration of a greater depth of soil, against which is to be set the greater loss of moisture. Whatever might be the net advantage of deeper tillage the fact remains that its general adoption is out of the question till the cattle have been materially improved.

Possible improvements.

A more valid criticism against the ordinary system of tillage is perhaps that it takes an excessive amount of time. When the weather is unfavourable, the number of different ploughings required cannot always be accomplished in the time available, and therefore either the seed is sown late (sometimes a serious disadvantage, as will appear further on), or it is sown on land that is not properly tilled. Adequate surface tillage can be effected more quickly if the first ploughing is done with an iron plough that does not merely push the soil aside, but lifts it and throws it over: this course, followed by a thorough stirring of the soil, will give a satisfactory tillage in much less time. The stirring can be done by the ordinary plough, but more quickly and efficiently by a "cultivator" or harrow: either implement consists in essentials of one or more rows of iron hoes fitted to a frame; the frame is drawn over the ground by bullocks and the hoes stir the soil. The difficulty in the way of this method of tillage lies in the cost of implements: under the present system a cultivator does pract-

cally all his tillage with a plough costing about three rupees. Under the alternative system he would still need this plough for use in sowing, etc. : he would also need an iron plough costing perhaps four or five rupees, and it would be advantageous to have a harrow or "cultivator" costing rather more. Thus the adoption of the alternative system is out of the question in the case of a man who owns only one plough (joint-ownership of implements would be objectionable in this case, as all the owners would want the implements at the same time). It would probably pay the better class of cultivator, the man who owns four or five ploughs, to keep one iron plough for the first tillage and a cheap harrow as well, and he would soon learn how to use the new implements without losing more moisture than the soil could spare ; but the small cultivator probably cannot afford to make the change, and must continue to employ the rather cumbrous but effective means that are now in use.

Use of the patah.

As has been noticed incidentally, the use of the clod-crusher (patah or patela) is not only to level the field and break the clods thrown up by the plough, but also by compacting the surface to bring moisture from the lower layers to the surface soil. If you go on working a plough in the upper three or four inches of soil, you get, it is true, a finely pulverised seed-bed, but it is often too dry ; the water which it contained has passed into the air, while the capillary movement of water from below is interrupted as we saw in a former chapter. When, however, this loose layer of soil is pressed down by the patah, the capillary movement is facilitated and water comes from below into the

surface soil. It will then be understood that it is as impossible to lay down rules for the use of the patah as for the use of the plough: the general principle is to use the patah when the surface soil is too dry for a proper seed-bed, so that it is more frequently used in the rabi than in the kharif, but it is used in the kharif too when the circumstances require it, and it is only by practical experience that its proper use can be learned.

General remarks.

The art of tillage then consists first and foremost in getting a proper seed-bed, that is to say, in having the soil just in the best condition for germination in respect of texture, warmth and moisture. If the seed-bed is much too cold or too hot, much too wet or too dry, the seed will not germinate at all; while even if the defect is only slight, the plants will start growing rather weaker than they should, and some of the seeds may not even start, so that on the whole the crop will be poorer than if the seed-bed were exactly right. The crops sown in the same seaon differ considerably in their requirements: for instance, the best seed-bed for gram is not altogether suitable for wheat; and the cultivator must, and does, know the requirements of each. If the field is too wet and too hot, he waits till it dries and cools,—processes which go on together; if it is too dry and too hot, he waters it so that it is cooled as the water dries; he scarcely ever has a field too dry and too cold except for sowing sugarcane, but if he has, he must wait till the sun warms it and then water it; while finally if it is too wet and too cold, he can usually do nothing but wait till the next season. In many cases he has to be content

with a field imperfectly pulverised, for if he waited to plough it oftener it would get too cold or too hot or too dry according to the season; thus a wet October means bad tillage for the rabi.

After the seed is sown the art of tillage consists in keeping the land free from weeds, and regulating the supply of moisture by loosening the surface or leaving it untouched; thus it is bad to hoe maize when the land is very wet, for then the superfluous water should be allowed to evaporate away as rapidly as possible, but if the field is getting too dry, it must be hoed at once to check the loss as much as possible. Alike before sowing and after sowing, judgment is required at every step, and sound judgment can be based only on long experience. Fortunately each cultivator has not to acquire all his experience by his own mistakes; he begins to work on his father's land, or perhaps goes out as a very small boy to work for wages, and by the time he comes to manage a holding of his own, the stock of experience he has acquired, together with the common knowledge of his neighbours, is usually sufficient to save him from the most serious mistakes. But there are great differences between individual cultivators in this matter of judgment; some men will be found in most castes and most villages with an almost unerring judgment, and others who never get the most out of their land. On the whole, however, the average is highest among those castes such as Kurmis and Lodhas who are by long custom cultivators and nothing more, and lowest among those who (like many Chhattris) think manual labour beneath their dignity, so long at least as they can afford to pay some one else to do it for them. But the least skilful cultivators are constantly being weeded out: when a

run of bad seasons sets in, they get behind with their rent and lose the whole or part of their land, which goes to those who have enough ability to enlarge their holdings; and thus the average of skill does not deteriorate but probably increases slowly from generation to generation.

CHAPTER VI.

SOWING AND SEED.

Time for sowing.

We have seen in the last chapter how the cultivator prepares a good seed-bed; the next operation is to put the seed in the ground. In this matter, as in tillage, the greatest difficulty is to know when to act. In ordinary seasons the cultivator rarely makes a mistake, but his experience is occasionally at fault in exceptional weather, and sometimes he has to take a good deal of risk. For instance, after the failure of the rains in 1896, it was of the utmost importance to each individual cultivator to get as large a rabi crop as possible: seed was no doubt very dear, but advances to meet its cost were readily given both by Government and by the majority of landlords, and so a large area was sown that would probably have been left fallow if the need of producing food had been less urgent, or if there had been less help in obtaining seed. Some of the fields so sown gave an adequate return, while others did not, but there is no doubt that the outturn of food was on the whole far higher than if the people had not been helped to sow. The principle thus established is that when there is a serious deficiency in the kharif and when the ground is rather dry in October, cultivators should be given every facility for obtaining seed and left to decide, each man for

himself, whether it is worth while to take the risk of sowing it. No one else, Government or landholder, can possibly decide this question: it must be left entirely to the individual cultivator.

A similar question will sometimes arise when the early rainfall in June and July is unusually light, and the principle is the same: at this season, however, the cultivator can usually afford to wait longer as there is always a chance of copious rain coming to change the situation, while rain in the end of October or early in November is exceedingly rare. A more common risk in the kharif is that heavy rain may come just after a large area has been sown: the soil will be for a time too wet for germination and the seed may either rot entirely, or at best germinate weakly or partially. This is a risk which the cultivator cannot avoid: if the seed is lost, there is usually time to resow the land if more seed can be got, so that the loss is not very serious: for instance, 20 lbs. of maize sown on an acre may yield 800 lbs. of grain, the net increase being 780 lbs.; if the field has to be sown twice over, the net increase is reduced to 760 lbs., not a very material difference. The loss of course is greater if a larger weight of seed has to be sown: wheat, for instance, requires about 100 to 120 lbs. to the acre. And there is often a difficulty in getting a fresh supply of seed: a cultivator who usually saves his own seed will as a rule have to buy his second supply when prices are very high and there is little money in the house, while a man who depends on his banker for seed may find difficulties in getting a second advance. The loss from the need of resowing is therefore very real, though it is not to be compared with that which results when the land cannot be sown at all.

Method of sowing.

If, however, we leave these questions out of consideration and assume that the state of the ground is favourable for sowing, the important points to consider are, first, the placing of the seed, and, secondly, its quality. We have seen in the first chapter that each plant requires a certain amount of space from which to draw its nourishment : if the plants are too crowded, individuals will be insufficiently fed, while if they are too far apart, space will be wasted and the outturn of the field as a whole will be reduced. The ideal system of spacing is to plant each seed separately after measuring the distance apart. This course is more or less followed in a few cases where the seed is very expensive ; seed-potatoes, for instance, are very costly, and these are sown in rows or drills separated by equal distances, while in each drill the potatoes are placed at equal distances apart: the distances are not actually measured with a rod, but they are approximately equal. The system of sowing sugarcane cuttings is practically the same.

This system takes a good deal of labour and time, and the cost increases as the individual seeds are smaller and as the quantity to be sown rises ; with crops of intermediate value, such as wheat or maize, another plan is followed, the seed being dropped by hand in a furrow or drill made by the plough. In this case the distance between the drills is regulated as each successive drill is made by the same plough working evenly : but the seed is dropped by hand in the drills in such a way that, while each plant is assured of sufficient room on two sides, on the other sides it may be crowded, or unnecessary space may be left. The result

can be seen by carefully examining a drill of wheat in an ordinary cultivator's field: here and there plants will be found crowded together, while elsewhere there will be blank spaces. A certain amount of loss results by this method of sowing, but it is not serious when the seed is dropped by a careful and experienced labourer : and in any case the cost of placing each seed separately in its exact position would probably outweigh the advantages to be obtained. With inferior crops again even the system of drilling is considered unnecessary expense and the seed is scattered broadcast over the ploughed field. In this case the spacing must always be defective, and an inexpert sower may cause considerable loss ; this system is therefore usually confined to those crops which will not pay for anything beyond the minimum of labour.

In some cases the patah is run over the field after the seed has been sown, while in others the surface of the land is left rough. Whether it is used or not depends on the state of the seed-bed ; if it is on the dry side, the patah will be used to enable moisture to rise from below, while if it is rather wet, it will be left to dry as quickly as possible. Hence the use of the patah after sowing is commoner in the rabi than in the kharif, and in the rabi it is most usual when there has been little rain in the end of September and the beginning of October.

Thinning and transplanting.

Whether the seed is sown broadcast or in drills, the cultivator as a rule uses a larger quantity than is actually required to cover land evenly. His object is to guard against some of the seed being dead and unable to germin-

ate, a common enough thing when he gets his seed from a grain dealer. If, then, all the seed germinates, some of the plants will be overcrowded, and it may be desirable to thin out a few in order to give the rest more room; this process is not common in the provinces. On the other hand, with some crops it is possible to fill up blanks that have been made by the seed failing; young wheat seedlings for instance can be taken from places where the field is over-crowded and planted in the blank spaces, but this requires much minute labour, and it is always doubtful whether the process pays its expenses. In other cases blanks can be filled by sowing more seed in holes opened by hand or with the khurpi; this, too, is a rare practice, but it may pay with crops such as maize and cotton where the number of plants in a field is comparatively small and even the loss of a few may make appreciable difference.

Thick and thin sowing.

The spacing of the plants in the field has a marked effect on the way in which they develop. As a general rule plants sown close together grow taller and with fewer branches than if the spaces between them were greater; consequently plants which by nature throw out several stems or branches each of which bears flowers and seed require more room, and therefore are sown more thinly than those that have a single stem with few branches or several stems growing up close together. Arhar, for instance, may be sown very thinly along with juar, but if the season suits it, it may grow so thick and bushy as to fill the whole field after the juar has been removed. The commonest practical use of

this principle is the sowing of juar for fodder: when this crop is sown mainly to produce grain, not more than ten or twelve pounds of seed go to the acre, but more than twice this quantity is sown for fodder; the plants are crowded close together and grow to a great height, so that the quantity of fodder gathered from an acre is much increased while (if they are allowed to form grain at all) the heads contain much less grain than where each plant has had a greater space. Again, hemp which is grown for the fibre contained in the stalk is sown very thickly so that the stalks, and therefore the fibre they contain, may be as long as possible. On the other hand, low, bushy crops like gram are sown thinly, so that the individual plants may not be crowded, and so stunted in their growth.

Quality of seed.

The quality of the seed is a most important question. In the ordinary course of things some of the seeds produced by a plant are in some way defective, that is, either they will not germinate at all or they will produce inferior plants which will yield at most a reduced quantity of inferior seed; and, on the other hand, some seeds will produce plants of exceptional health and vigour. The proper choice of seed is therefore an important matter: in an ordinary lot of seed it is not unusual for ten per cent or more to be bad; this would mean a corresponding reduction in the outturn, but as we have seen the cultivator usually endeavours to protect himself from the loss by sowing more seed than is actually needed. This course involves a certain amount of waste due to faulty spacing as there is no certainty that the bad seed will be evenly distributed, but it

minimises the loss at the cost of the extra seed required. In some cases, too, the loss can be further reduced by transplanting, but undoubtedly the best course is to sow good seed, and it is a course which the cultivator adopts when he can.

Seed supply.

It must be remembered that the ordinary cultivator cannot go into one of a number of shops and choose the seed that he thinks will suit him: if he is fairly prosperous, he will have saved his seed from the previous year: otherwise he is dependent on the grain dealer who finances him. Now a cultivator may either take only the best seed, or he may take all that is not bad. The former course, which is usually called seed-selection, will in ordinary circumstances lead to a gradual improvement in the crop; the latter will prevent a gradual deterioration.

Seed selection.

Seed selection is commonly practised over large parts of the provinces in connection with certain crops. Its action is based on the great principle of inheritance, that while two plants are hardly ever alike in all respects, plants tend on the whole to resemble their parents. Thus, if a cultivator picks out, say, the fifty finest plants in a field and saves their produce for seed, he can be confident that the plants raised from this seed will, on the whole, be at least as good as the parents, and he may often hope that on the average they will be rather better. The term "finest" which has just been used means most suited to the purpose for which the crop is grown: if it is a grain crop, the finest

plant is ordinarily that which yields the greatest quantity of good grain. The crop of which seed is most commonly selected is juar: if you see a cultivator in the central duab starting to thresh his juar, you will most probably see that he puts aside a small pile of the largest heads, and he will tell you that he is saving these for seed. Similarly for maize the finest cobs are often set aside, and I have been told that some of the western cultivators even choose wheat seed in the same way. The process is certainly desirable in all cases, but as with so many other desirable processes the question arises whether it is worth the labour. The labour depends on the ease with which individual differences can be recognised: now juar and maize are just the crops where the ease is greatest, for a man with any experience can see at a glance which heads or cobs are the best, and he can do the selection on the threshing floor as juar has only one head and country maize not (as a rule) more than two cobs to the plant. With wheat, on the other hand, where the productivity depends so largely on the number of ears to the plant, the choice must be made in the field while the plants are standing, and any one who cares to try the experiment will find it a matter of considerable difficulty to pick out the best plants even in a half-acre field. With crops such as peas or urd, again, the plants are so much intertwined that selection becomes almost impossible. These facts explain the apparent anomaly that many cultivators select from such inferior crops as juar, while they do not select from wheat: and a further explanation is to be found in the fact that men can afford to keep a few pounds of juar seed though they have to sell (or hand over to their bankers) the whole produce of their

wheat. Seed selection is thus limited not only by practical difficulties but by economic considerations.

Seed rejection.

The alternative to seed selection is to reject those seeds which are noticeably bad and sow all the rest. Some of the most careful cultivators habitually hand-pick their seed, rejecting any seed that looks abnormal : I have seen this done even with such a cheap crop as urd, and a very laborious process it is. A readier, but not so effective, method is to pass the seed over a sieve, rejecting all under-sized seeds (as small size as a rule indicates weak or defective seed), and this also is commonly practised ; but many cultivators sow all the seed they can procure without separating out the defective seeds or impurities, taking in fact what is given to them, though they appreciate highly an offer of better seed.

Deterioration of seed stocks.

Thus no improvement in the local agriculture is needed more urgently than increased facilities for obtaining good seed. It must be recognised that under present conditions the chances are in favour of a progressive deterioration of the crops in those cases where the seed is advanced by the grain dealer. A grain dealer receives at harvest a large quantity of wheat (for instance), some of which he will keep for issue of seed next season while the rest he will sell in the towns for consumption as flour. Now the price of what he sells depends on its quality, while he can advance any quality he likes for seed. It is not in human nature that the average dealer should keep his best wheat for sowing :

the ordinary man will sell the best and keep for sowing that which would command the lowest price : in other words, the process at work is the selection of the worst, not the best seed, and this process must lead to gradual deterioration. The importance of this question to the country is obvious.

Change of seed.

Another point of interest in connection with seed is that if seed from the same stock is sown year after year in the same locality, the produce tends to deteriorate : it is a great advantage occasionally to obtain seed from some distance. This of course is impossible for the ordinary cultivator ; but the benefit is secured to some extent as a result of the periodical scarcities when local supplies become insufficient and large quantities of seed-grain have to be imported from elsewhere. Whether anything more can be done in this direction is a question that depends on some alteration in the existing methods of seed supply—too large a question to be discussed here.

CHAPTER VII.

IRRIGATION.

Introductory.

THE cultivator can conserve by proper tillage much of the natural water supply for the benefit of his crops, and there are some regions in the plains where the supply in ordinary seasons is about sufficient for his needs. This is the case in most of the river valleys, and also in a large part of the sub-montane tracts where the heavier rainfall and the drainage from the higher ground combine to keep the land sufficiently

moist. Over the greater part of the duab, however, irrigation is necessary to make the best use of the land in the rabi season, and to tide over dry periods in the kharif.

Sources of irrigation.

The first question is, where to get water, the second, how it can best be used. The sources available are (1) canals bringing water from the great rivers; (2) local streams, jhils and tanks; (3) wells.

We are not concerned with the construction or management of the canal systems, which are in charge of an expert department; the water is laid on in a series of channels, from which the cultivator has merely to apply it to his field, raising it where necessary.

Streams and jhils.

The use of local streams and jhils is largely governed by customs (which are as a rule recorded in the village papers) securing to different interests something like a fair share of the limited supply of water available. In fact the limitation of the supply is the distinguishing feature of these sources: they can usually be drawn on for late rice and for the first watering of the rabi, but in a dry season they commonly prove insufficient even for these purposes, and it is only rarely that they can be relied on for a second rabi watering. In fact it may be said of these sources that the greater the need the less help can they give.

Tanks.

The term *tank* has different meanings in different parts of India, and these must be clearly distinguished. In more or less hilly tracts, a description which covers part of Bundel-

khand, a tank is a reservoir formed by damming up a valley between two hills : the reservoir catches the rainfall on the hills, and water is let out from it to the lands lying at a lower level : in addition the soakage from it keeps the land below the dam much moister than it would otherwise be. Tanks of this description are unknown in the duab. Here a tank means simply an excavation in the level ground : the earth excavated is thrown up round the edges, gaps being provided by which the surface drainage from the neighbouring land can flow into the excavation. These tanks are not capable of assisting irrigation on a large scale. They are usually shallow (as the cost of excavation increases greatly with the depth), so that the amount of water stored is not great, and it diminishes rapidly by evaporation in hot and dry weather. Further, as with jhils, tanks hold least water when most is wanted. Tanks are not, however, useless : near houses they are most useful for watering cattle and for various domestic purposes, and in ordinary years they can usually give a first watering to a certain amount of land ; they cannot, however, serve as an efficient protection against drought. The chief point to attend to in their construction is the nature of the soil : the bottom of the tank should be a thick layer of clay, which will, as we have seen, serve to keep the water from draining away : it is often possible to dig a tank too deep, and cases are known where in the attempt to increase the value of a tank all the clay bottom has been dug out and a sandy bottom left which held no water at all. Such a mistake would not be made by a practical cultivator, but is not unlikely to occur when a tank is being made by an ignorant land agent.

Wells.

Finally there are wells, the most important source of all. The simplest kind of well is made where the surface soil is immediately underlaid by a fair thickness of sandy loam resting on clay. A hole is dug into the sandy loam, which at the end of the rains is naturally more or less saturated with water, and the water collects in the hole from which it can be drawn out as required. Such wells are exceedingly cheap, costing perhaps a rupee to construct, but they have many disadvantages. There is not, as a rule, a great depth of sandy loam, or if there is the well cannot be sunk deep into it, because the loose wet loam of the sides will not stand unsupported, but falls in and blocks the well : again, the supply of water is reduced by evaporation at the surface of the soil, so that these wells will not yield a great flow of water and may fail towards the end of a dry season. Again, they are almost certain to fall in during the rains as the sides have not sufficient stability to remain in position when thoroughly saturated, so that the well lasts only for one season. Notwithstanding these drawbacks, where the soil and climate are suitable, such wells are of the utmost use : the capital cost is nominal (in fact the well is often made by the cultivator with the labour of his family), and the water is so near the surface that it can be raised with very little cost : a well, too, can be made wherever it is wanted, so that there is little loss of water after it has been raised to the surface. Such wells are known as *percolation wells*.

Where percolation wells cannot be made owing to the nature of the soil, a *spring well* is the usual resource. We have seen in the previous chapter that in many places there

are large beds of saturated sand more or less enclosed in clay : a spring well is one which draws water from one of these underground sand-beds. The well is sunk down to the clay overlying the sand and a hole is then driven through the clay bed : the water rises through this hole and fills the well to a height which depends on the size and position of the sand-bed in a way that can hardly be explained in a popular manner. These wells have this advantage over percolation wells that the supply of water is ordinarily much greater, and that being at a greater depth from the surface it is less liable to loss from evaporation. This greater depth, on the other hand, involves more expense in raising the water, while in many cases the well has to be lined to keep the sides from falling in. The great value of these wells is that they can be relied on in years of drought when streams and tanks have dried up, and percolation wells are liable to fail. It is of course conceivable that a severe drought should result in these underground sand-beds being drained of their water, but this is not known to have occurred over any considerable area in the Gangetic plain.

We have just mentioned that the sides of a spring well may need protection : it is the extent of this need which mainly determines the cost of making a well. Where the soil is underlaid by clay or heavy loam it may be possible to do without any protection, as the earth at the sides will retain its place even when wet. Deep unprotected wells of this sort may last for a long term of years, but they will eventually wear out as the slow oozing from the sides and the splash of water spilt from the bucket tend to loosen the earth and make it fall into the well. Where experience

shows that an unprotected well will last for ten years or more it is usually the best finance to re-excavate it as required : when it will not last for so long, the question whether it is better to protect the sides depends partly on the expenditure involved and partly on the ease with which capital can be obtained—both factors which vary widely in individual cases.

It may, however, happen that the well has to pass through a shallow bed of sand (too shallow to give an adequate water supply) ; if this is left unprotected, the sand soon falls into the well, bringing with it the loam or clay which rested on it, and the well is spoilt. Very ingenious methods have been devised by cultivators for preventing this injury : the commonest is to protect the weak part of the well by a thick rope of twigs coiled round it : arhar stalks and the coarsest high grasses are usually employed for this purpose. Sometimes a hollow cylinder of arhar stalks is woven basket-fashion and fixed in the weak place ; sometimes the cylinder is built of pieces of wood pegged together ; and sometimes the weak place is lined with bricks resting on a shelf or bevel cut in the well. Cylinders of corrugated iron can also be employed : they cost more than the other devices but last longer.

Masonry wells.

If however the soil down to the clay is all sandy, or if there are numerous bands of sand, the whole well must be lined. Either the well may be dug in the usual way and then lined from the bottom with bricks uncemented or cemented only with mud, or a masonry cylinder (strengthened sometimes with iron rods or bands) is built at the surface of the land

and gradually sunk by digging the earth from beneath it, until the clay bed on which it is to rest is reached.

There are many important points in this operation which we cannot deal with fully : the practical work of sinking a cylinder must be carried out either by a professional engineer or by a practical builder who has experience of what has to be done. One great danger is the use of bad mortar, which may lead to the cylinder breaking : another is that it may be sunk crooked, usually with the same result. Or again, even if the cylinder has been sunk properly, the clay bed may not be strong enough to support it : some sand always flows with the water into a well, so that a cavity soon forms under the clay, and if the layer of clay is thin the weight of the cylinder may break this and the cylinder get crooked and crack.

Apart then from the use of good materials and the employment of careful workmen, the great point in undertaking the expensive work of sinking a masonry well is to be reasonably sure that (1) a bed of saturated sand exists at a reasonable depth, and (2) that it is covered by a layer of clay sufficiently thick to support the cylinder that will rest on it. In popular language you must first be sure that you have *mota*. Now the greater portion of the well-irrigated area in the Gangetic plain has the *mota*, but it is not universal : from Aligarh northwards such a layer of clay is found only in patches, and further east there are numerous localities where the layer is too thin to support a well or is altogether absent. In villages where wells are numerous the cultivators rarely or never make a mistake in locating the site of a well : the localities which should be avoided have been learned by experience which is carefully treasured up. But in a locality where failures have been

frequent, cultivators dare not risk making a well which past experience shows is likely to be a failure: hence these localities remain unirrigated and are liable to serious injury in dry years. In all such cases, where the cultivators are doubtful whether a well can be sunk, it is advisable to begin by taking trial borings. A boring is simply a narrow hole sunk in the earth by an auger or other tool: the earth brought up by it is noticed and a person trained in the art can infer with certainty from these indications whether a well can be sunk or not. This precaution should always be taken when it is desired to sink a well in a place where a cultivator is not willing to take the risk.

It occasionally happens that a well is a failure: it goes wrong in sinking, or though properly sunk very little water flows into it. In such cases it is not necessary to pronounce the well useless: a defective well can often be cured by an expert. We cannot describe here the defects that may occur or the remedies that should be applied, and must leave the subject as one on which the ordinary person should be content to obtain expert advice.

Methods of raising water.

As a rule the water available is at a lower level than the field which it is desirable to irrigate, the only exception being where a canal flows above the level of the surrounding land, or in hilly country where a tank (in the Bundelkhand sense) waters land below its embankment, or where a stream can be carried in branches over sloping ground. The first thing in utilizing the water is therefore to raise it to the required level. The best means of doing this depend on the height to which the water has to be raised.

For lifts of less than four feet, the ordinary implement is a closely woven basket held at the ends by ropes. This is worked by two labourers who swing the basket into the water and then empty it at the higher level into the channel by which it is meant to flow. This is hard work, and four men working by turns must be employed to each lift : the merit of the system is that it involves little capital cost, while its defects are (1) that a good deal of water falls back each time the basket is raised : (2) useless work is expended on raising the basket : (3) the process is slow. When the rise is up to eight or nine feet, two lifts have to be employed each with four men. An alternative to the basket lift is the chain pump which consists of a series of discs on an endless chain, passing over a wheel and through a pipe : as the wheel is turned, the discs rising through the pipe bring up a constant stream of water. A small pump of this sort can be worked by a gang of four men, the same number as a basket lift : when properly fitted there is no loss by spilling, nor is there any useless work, as the chain and discs coming up are counter-balanced by the chain and discs going down. This pump can do better work than a single basket-lift, but its efficiency is greatest between five and twelve feet as it can then replace two lifts instead of one. Its draw-back is its first cost (Rs.30 to Rs.40) which puts it out of the reach of the ordinary cultivator. It is however extensively used by cultivators who have a large area under crops such as cane and potatoes, which require large quantities of water. Two pumps of this kind can be geared together and worked by a pair of bullocks : this forms a most efficient lift, but the cost of gearing is so great that only the largest cultivators can afford it. A simpler lift (the Baldeo)

is made on a different plan to be worked by cattle, but its practical efficiency has not yet been fully determined and it is in use in only a few places.

Canals are usually so planned that the lift does not exceed eight or nine feet, and this is the usual limit also with jhils and tanks, though in special cases water is raised from these sources by three, four or even five successive basket lifts. For percolation wells (say six to fifteen feet deep) there are two common lifts, the *charkhi* and the *dhenkli*. These are simple arrangements for lifting a jar of water and counterpoising the weight of the jar, and can be understood at a glance. For deeper wells, it is usual to raise the water in a leather bucket drawn by cattle walking down an inclined plane. For lifts over fifteen feet no cheap lift has yet been devised which can compete with this indigenous system. The inclined plane is worked on different methods in the east and the west of the provinces: in the west, two pairs of bullocks are used to each lift, one pair coming up to the well while the other pair raise the bucket; while in the east, the work is done by a single pair. The western system (known as *kili*) saves time, and is less severe on the bullocks which do not undergo a sudden jerk as the empty bucket is returned to the well: the eastern system (lagor) involves less capital expenditure on bullocks, and is therefore more suited to the means of small cultivators.

The form of lift known as the Persian wheel is in common use with wells in the extreme north and extreme south of the provinces, but is unknown in the intervening country. It consists of a rough frame-work, working in the mouth of the well with an endless string of earthen

pots hanging on it: as the drum is turned by a rough wooden gearing worked by cattle, the full pots come up out of the water and empty into a trough. This arrangement appears to be less effective than the inclined plane, but the two have not been exhaustively compared.

Application of water to the land.

The proper application of water to the land is a matter requiring much experience and judgment, and also a certain amount of luck. No rules can be given for judging when a field requires water: and a cultivator is often tempted to withhold water for a few days in the hope of rain. If the rain does not come, the growth of his crop is injured: but, on the other hand, if rain comes just after irrigation, some of the land may get temporarily water-logged, and at least equal injury result.

The amount of water required and the number of waterings vary with the crop and with the soil. Particulars regarding the needs of each crop will be found in the detailed description given further on: as regards the soil, it will be remembered that plants require a continuous supply of water, adequate but not excessive. Now, as a field can only be irrigated from time to time, it is obvious that its soil will be sometimes rather too wet and sometimes rather too dry for the best possible growth: hence frequent light irrigation is desirable in preference to a single heavy soaking; but the cultivator is a busy man and must attend to all his land in turn, and in practice he arrives at a rough sort of compromise, giving more water on fewer occasions than is desirable. Again, it is obvious from what we have

seen regarding drainage, that a well drained sandy soil will require far more water than a rich loam to keep it in condition: in fact the very sandy soils require so much water that they are practically never irrigated. On the other hand, the heaviest clays are seldom or never irrigated in the cold weather, as the effect of watering these is to waterlog the surface. Between these two extremes the cultivator regulates the amount of water to the best of his ability so as to give the plants the greatest chance of favourable growth: the practice of the skilled cultivator cannot be improved in this respect. In one point, however, practice is frequently defective, for when canal water can flow on to the lands, too much is very often used at one time. Where water has to be raised, the cost and labour of raising it ensure that there is no excess, but when it flows freely, less care is taken and the lower parts of a field are apt to get swamped.

Another point of importance is to see that each part of the field gets its fair share of water. This is usually effected by dividing the field into compartments by low ridges of earth (known as *kiari*), as soon as the seed has been sown. The water is then allowed to run into each compartment in turn till it is sufficiently moist. Obviously the smaller the compartments, the more evenly can the water be distributed; but, on the other hand, smaller compartments involve more labour both in construction and in watering, and here again the cultivator effects a compromise. The most valuable crops get the smallest compartments as we can see if we compare a poppy field with a barley field: and the greater the cost of raising water the smaller are the compartments, so that generally speaking the size of the

compartments is smaller in well-tracts than in canal-tracts, and within canal-tracts is smaller for lift than for flush irrigation.

Relative value of canals and wells.

The question is often asked whether well or canal irrigation is best. Now there is no doubt that for all ordinary crops canal irrigation is easier : consequently canals will as a rule supersede wells where they come into competition. In special cases, however, wells may still be preferred, the reason being that the water contains some valuable plant food. This is specially true of wells near houses, which contain the substance known as saltpetre, composed of potash and combined nitrogen : this is an admirable manure for most crops, especially for tobacco, and so we find that tobacco is, where possible, irrigated from such wells. It must not be supposed that canal water contains no plant food : the fine silt which it carries contains a certain amount of mineral plant food, while combined nitrogen is also present, derived partly from the rain water and partly from organic substances which have fallen into the water and decayed. But the manurial value of canal water is nothing like that of a well very rich in saltpetre, though it may be equal to that of a well in the open country.

To sum up, in irrigation as in tillage, the average cultivator has little to learn. His success is conditioned by the capital he can command, and for want of capital he often has to put up with an inadequate supply of water and with inefficient means of raising it to the surface. It follows that the greatest benefit a landholder can confer on his estate

is to ensure an efficient water-supply for all land where irrigation is possible.

Note to Chapter VII.

An immense mass of information on wells will be found in the papers relating to the construction of wells for irrigation, published in 1883, by the College Press at Roorkee. The theory of wells is concisely explained in "Irrigation Wells in the western portion of the North-West Provinces," by Mr. E. A. Molony (Allahabad Government Press). For a discussion of the wider principles of irrigation the reader may be referred to the Report of the Irrigation Commission of 1901—03.

CHAPTER VIII.

MANURING.

Supply of mineral plant food.

As we have seen in the first chapter, all crops take some plant food from the soil, so that in process of time the mineral plant food must decrease in quantity. But the reserve supply is so great and the amount consumed is so small that this question is not of immediate practical importance in the case of ordinary cultivators : further, little of the mineral plant food can be absolutely lost as neither potash nor phosporic acid can pass away into the air, and therefore these substances return to the soil in ashes, excrement or decayed matter, so long as the produce of the land is consumed on it. Where, however, the produce is exported, the land is certainly impoverished : and to this extent the provinces lose mainly by their export of oilseeds and of bones, the latter containing large quantities of phosphoric acid. Under the existing conditions, however, these exports must continue though they undoubtedly represent a sale of part of the capital of the country ;

the cultivator does all he can when he sees that the ashes or refuse of whatever is consumed goes back to the land.

Supply of combined nitrogen.

As regards combined nitrogen the position is different as there is a comparatively small reserve stock in the soil, and much is lost through the use of cowdung for fuel, while, on the other hand, fresh supplies can be secured by the growth of certain kinds of crops. On the whole, the most important practical question is the preservation of the nitrogenous manure available in the village. The main substances which the cultivator has at his disposal are (1) human excrement, (2) human urine, (3) excrement of cattle, (4) urine of cattle, (5) dead leaves, stalks, wool, hair, and household refuse generally.

Use of human excrement.

The disposal of human excrement and urine is governed by the social habits of the people and there is no prospect of any regular system of sanitation being introduced in the villages; as a matter of fact, however, much of the excrement does go to enrich the soil of the fields close to the houses, and even the portion which is deposited on waste spaces in the village is not wholly lost, as some of the products of its decomposition find their way into the underground water and so into wells; but it would be a distinct benefit to agriculture as well as to sanitation if public opinion should prevent the pollution of the village-site and require all excrement (solid and liquid) to be deposited in the fields. In towns which are too large for the population

to be within easy reach of the fields, the excrement is removed by sweepers, and either sold to those cultivators whose caste rules permit them to handle it or else buried in the ground. The latter course is usual in the neighbourhood of the larger towns : ordinarily a pit is filled with excrement and then covered with earth : after sufficient time for the putrefactive processes to go on, the pit will contain a dark substance which can be handled without offence and is known technically as poudrette : it is an exceedingly valuable manure, containing large quantities of combined nitrogen, and is used for the more expensive crops, such as potatoes, vegetables and sugarcane. This system does not, however, save all the combined nitrogen of the excrement : the aggregation of large masses, with insufficient access of air, is not the most favourable condition for the bacteria which would effect putrefaction in the most desirable way, and considerable quantities of combined nitrogen escape in the form of ammonia, the pungent smell of which (flavoured by other products of decay) is a permanent feature of the localities where excrement is buried. An alternative system which is pursued in many cantonments is to bury the excrement in very thin layers in shallow trenches and to cultivate the land as soon as putrefaction is complete. This system, which is to be preferred on sanitary grounds, is also effective from the agricultural point of view, as the loss of nitrogen is much less : it requires, however, a very large area to deal with any considerable amount of excrement, and it is not wholly satisfactory in heavy clay, where the soil is not easily penetrated by air. The best results are obtained with light sandy soil.

Various other methods of sanitation are now on their trial, the common feature of which is that the excrement is caused to putrify not in earth but in water, so that the combined nitrogen dissolves in the water, which can then be used both for irrigation and manuring. These methods have not yet been applied to the sewage of any large population in these provinces, and need not be discussed here. It must be recognised that the disposal of excrement is primarily a question of sanitation; the agriculturist has merely to make the best use of the material which the sanitary authorities provide.

Excrement of cattle.

Next as regards cattle excrement. The value of cowdung as a manure is well known to the cultivators, and if they burn the dung instead of applying it to their land it is mainly because they cannot obtain other fuel; to a certain extent also cowdung has special advantages as fuel in that it keeps alight for a long time with little consumption. Whether landholders can profitably take steps by providing other fuel to save the cowdung for the land is a question the answer to which depends on the resources of individual estates; it may be noted, however, that a custom frequently prevails under which so many months' dung is kept for fuel, while the balance is set aside for manure, and that of course the ways of individual cultivators differ enormously; the good cultivator is careful of his dung-pit.

Dung-pits.

The best results are not obtained by putting dung on the land while fresh; it is better to keep it together till it has

rotted, that is, till the combined nitrogen has come into a state where it is available for plant food. The method of storing is most important, as bad storage may lead to considerable loss, and the cultivators of these provinces are perhaps less skilful in this than in most branches of their work. To begin with, the dung-pit should be out of the reach of rain, as water will wash out of it such portions of the combined nitrogen as have become ready for plant food: the pit should therefore be protected by some sort of a roof, and it should have low walls to prevent surface water flowing into it. Secondly, much depends on the conditions under which putrefaction takes place: we must regard a dung-pit as swarming with many different kinds of bacteria or small living beings, each of which wants to feed on some part of the contents; some kinds of these living beings will waste the combined nitrogen, while others will put it into a proper form; each kind will thrive best under certain conditions of moisture, temperature and æration, and the cultivator's object should be to keep his dung at such a heat and so supplied with air and moisture that the beneficial bacteria will thrive and multiply and the harmful species will find it difficult to exist. There should not be too much air inside the heap of dung, or in other words, it should be fairly closely packed; the heap should not be too dry, so that in hot weather it is desirable to sprinkle occasionally with a very little water. If these conditions are fulfilled, and especially if the free access of water is prevented in the manner described above, all that the cultivator can do will have been done.

Urine.

If much of the cowdung is lost to the land, the case is even worse with the urine, hardly any of which reaches its

proper destination unless actually voided in the field or soaked up in the dung used for manure. It is not desirable to collect the urine as a liquid and put it while fresh on the land, and if desirable it would not be practicable. In most countries cattle have litter (straw, leaves, etc.) put in their stalls for warmth : much of the urine is soaked up by this, and as the litter when foul is thrown on to the manure heap the urine reaches its proper destination. In the greater part of these provinces the cattle have to do without litter, as the straw is needed for fodder, and what dead leaves are available are used for fuel : the cattle therefore when not at work stand on bare earth, into which the urine soaks and is lost. It can however be saved very cheaply and effectively wherever the cattle are kept under a roof : all that is necessary is to puddle the earthen floor, make it slope slightly towards a hole containing an earthen pot, and keep a little loose dry earth sprinkled on the floor. Of the urine which falls, some flows into the pot and the rest is soaked up by the loose earth : this loose earth should be changed daily, what has been used being thrown into a sheltered pit and the contents of the pot emptied over it. In this way the pit is gradually filled with earth into which all the urine has soaked : putrefaction goes on rapidly, and in a short time the earth so used contains about as much combined nitrogen ready for plant food as the same weight of cowdung would yield. The work to be done is within the capacity of a child, so that the ordinary cultivator can thus treble or quadruple his manure supply at practically no expense.

Other refuse.

As regards the other refuse of the house, it is usually pitted along with the dung, and the organic matter rots in the same

way, while the mineral matter contained in the ashes is unchanged. The mixture so obtained is spread over the field to be manured, and the field is then ploughed so as to mix the manure with the soil before the seed is sown. Occasionally however dung is scattered in small pieces over land on which vegetables or valuable crops such as poppy and tobacco have been sown.

Urine earth, prepared in the manner described above, can be applied either as ordinary manure or else scattered over growing crops. Used in the former method it may even be more useful than cowdung, as the latter attracts large numbers of white-ants, which attack certain kinds of crops, while they are not attracted by the urine earth. If used as a *top-dressing*, that is applied to a growing crop, urine earth gives excellent results, as most of the combined nitrogen in it is in a soluble form ready to pass directly into the plant.

Feeding cattle on the land.

It is not absolutely necessary to keep the dung and urine near the cattle-shed and then carry it to the field : in many countries it is usual to feed the cattle on the land to be manured and leave their dung and urine to work into the soil ; thus fodder crops, such as turnips, are largely fed on the land. In the duab this practice does not prevail : in many parts the cultivator cannot spare any part of his land solely for fodder crops, but must grow crops which will feed himself and his family as well as his cattle, while in the west, where the larger holdings allow of the growth of fodder crops, the need for tilling the land as soon as the fodder can be cut, the risk of theft if valuable animals are left out at night, and the want of fencing combine to make it better to

carry the fodder to the house ; but it is a common practice in the eastern districts to keep sheep on land that is to be put under sugarcane. The sheep, which naturally feed very closely, eat the stubble and weeds that are on the land, and leave their dung and urine on it ; in other words, they are employed to turn the weeds, stubble and any other food they can pick up into manure containing its combined nitrogen. That the cultivator considers this a benefit is shown by the fact that he makes a small payment to the sheep-owner for the use of the sheep.

Special manures.

The cultivator has, in addition to dung, urine and miscellaneous refuse, a few special manures at his disposal. One of these is saltpetre, which is very valuable as containing both potash and combined nitrogen in a form which can be taken up directly by the plant. Where this substance is available it is used in small quantities as a top-dressing for valuable crops. It is found mixed with other substances in places which have been inhabited for a long period : in such cases the ground always receives a large quantity of combined nitrogen, especially in the form of urine : this is "worked up" by the bacteria in the soil and unites with the potash present there, and eventually makes its appearance as a white incrustation on the surface of the ground. This is of course mixed with earth, and the mixture is used under the name of *nona mitti*.

Another special manure is the substance, known as cake, which remains when oil has been pressed from seeds. In most cases this is too valuable to be used as manure, as it is an excellent cattle food ; indeed til-cake is occasionally

eaten by human beings; but castor-cake has certain medicinal properties which prevent its use as a cattle food. Now we have seen that in oil-seeds there are two principal classes of substances: (1) the oil, and (2) the substances containing combined nitrogen. When the oil has been removed, the residue contains a great deal of the latter substances and makes an admirable manure for such crops as the better kinds of sugarcane. The quantity available for this purpose is of course small.

As has been said above, bones contain a great deal of phosphoric acid and also a certain amount of combined nitrogen; they have therefore a considerable value as manure. Unfortunately, however, these substances are not in a condition to be used by plants, and bones decay very slowly. In many countries they are made into an excellent manure by treatment with sulphuric acid, the product being known as superphosphate or dissolved bones. The cost of sulphuric acid in these provinces renders this treatment commercially impossible, and the only way known of utilising the bones is to grind them into powder before putting them on the land. This grinding accelerates the changes which are required to make the bones readily available, though the product (known as bone-meal or bone-dust according to the fineness) is still a slow-acting manure; and whether the substance will come into use depends mainly on the cost at which this grinding can be done, though it must be remembered that many castes have a prejudice against handling bones. At present its use is trifling.

In most countries minerals containing potash or phosphoric acid are largely applied as manures, but their use in the duab is economically impossible: they do not exist on the

spot and the cost of bringing them from long distances is prohibitive.

As regards the distribution of manure over the various parts of a cultivator's holding, something has been said in the chapter on soils, and we shall return to the subject when dealing with the management of a holding.

Note to Chapter. VIII.

Detailed descriptions of various methods of saving dung and urine will be found in *Bulletin* No. 14 of the Agricultural Series, published by the Superintendent of the Allahabad Government Press. A good summary of what is known regarding the rotting of manure will be found in "Agricultural Bacteriology" by H. W. Conn (London, Rebman). "The Farm Manual," published by the Superintendent of Government Printing at Calcutta, may be referred to for an account of the shallow-trench system of disposing of refuse.

CHAPTER IX.

HARVESTING, PAYMENT OF RENT AND DISPOSAL OF PRODUCE.

Time of harvesting.

The right time to harvest a crop cannot be ascertained by reference to rules, but can only be learned by experience. A crop has to be harvested as soon as it is ripe, since a ripe crop standing in the field very soon deteriorates : some of it is stolen, some taken by birds or animals, or knocked off the plant by wind or rain, while in some cases, especially sugarcane, the composition of the produce undergoes rapid changes. Ripeness in fact means that the produce has just reached the stage where it is most valuable for the cultivator's purposes.

Harvesting of some crop or another is going on almost throughout the year from August to May. In August indigo is being cut and the first of the small millets are

ripening. In September the maize harvest is in full swing and the earlier rices are being cut : the main kharif harvest (millets, pulses, cotton and, finally, late rice) goes on from October to December, by which time the earliest sugarcane is ready for pressing. This operation continues till February or March, and as soon as it is over the earliest of the spring pulses are ready to be gathered ; then follows the wheat and barley harvest, which lasts till about the end of April. Meanwhile all sorts of minor crops have been gathered : potatoes come in during February, a large variety of melons, cucumbers and pumpkins at intervals from April till October, the hot-weather millet (known as either *chehna* or *sawan*) during May and June, and the mango crop in the same months. The rabi ripens much earlier in the east than in the west ; there is nearly a full month's difference between Benares and Meerut. The prolonged cold weather in the west accounts for the difference as up to a certain point plants mature quicker, the higher the temperature. In the kharif season, on the other hand, the crops usually mature earlier in the west, where the rain of September is as a rule less copious than in the east.

Methods of harvesting.

There are two main methods of harvesting besides numerous special methods applicable to particular crops. Where the ears of grain are comparatively few and conspicuous it is usual to cut them off and get out the grain separate from the rest of the plant. This is done in the case of juar, bajra and maize : in the first two the ears are placed on a bare piece of ground and cattle driven round and round over them : the feet of the cattle gradually knock

the grain out of the ear, and in time (for it is a tedious process) all the grain is separated. As soon as this point is reached the grain is winnowed: this is done by lifting up the stuff that has been trodden and letting it fall in a current of wind; the grain is heavy and falls straight to the ground, while the fragments of the heads are lighter and are blown a little distance off. The grain thus accumulates in one heap and the broken heads, or chaff, in another.

In the case of maize the cobs (as the heads of grain are called) are not trodden out, as this would damage the bulky seed, but beaten with stricks till the grain falls off. This method of beating is also practiced with some other crops: either the ripe plants are beaten with sticks or they are themselves beaten against the ground till the grain falls out.

With most of the crops that produce large numbers of heads of grain, the whole crop, not the heads only, is put on the threshing-floor and trodden out by cattle, and the grain is then winnowed out by the method just described. This is done with wheat, barley, most of the pulses, and various other crops. Winnowing, which looks so simple, really needs a good deal of skill in order to judge the best height from which the grain should fall and the speed of its descent. Given this skill it is a most efficient process, and the grain is left in a heap wonderfully free from chaff and dust; the chief drawback is that sometimes in November and December the wind fails, and it becomes necessary to create a current of air by waving a blanket or cloth; failure of the wind need hardly ever be feared in March or April.

The method of harvesting naturally affects the state in which the rest of the plant is left. When the ears are

trodden out separately the plant is left unbroken; in some parts of the country the juar and bajra stalks are left standing in the field till wanted for fodder, while elsewhere they are cut and stacked in the field or stored in the house. Before using for fodder they are chopped up into pieces of half an inch to an inch long, which are easier for the cattle to eat than the long stems. Maize stems are very innutritious and are hardly ever given to the cattle in these provinces, but are used for fuel. Where the whole crop has been trodden, the plant is left broken into small pieces which can be given to cattle without further preparation.

The special methods of harvesting are employed mainly with those crops which are grown not for food but for some other product. Thus the whole indigo plant is cut when green and steeped in water to extract the dye: the cotton pods are picked separately by hand and the fibre removed from the seed by a process known as ginning; hemp is soaked in water to rot the stems, which are then beaten till the fibre is freed; the heads of the poppy are lanced and the opium that oozes out is scraped off; the leaves of the tobacco are picked and dried in the sun, and so on. Again, we have seen that some food crops are grown not for the seed but for the reserve of nourishment which the plants store under ground; in these cases the crop is harvested simply by digging up the store when it is fully accumulated, as with potatoes, radishes, yams and various other vegetables. Sugarcane is treated by a separate process: the juice is pressed out of the canes as soon as they are cut and is boiled down till the whole is obtained as a solid or a thick liquid. These special processes will be described in connection with the crops to which they are applied.

Defective methods.

It is important to remember that these methods of harvesting, which cultivators have worked out for themselves in the course of centuries, are adapted primarily to their own needs, since there was no possibility of exporting ordinary produce until quite recently. It is therefore only to be expected that their methods occasionally produce results that are not welcomed in European markets. This is least noticeable in the case of grain ; all that any one wants is to have his grain unbruised and free from other substances, and the cultivator's methods give this result very fairly. It is true that Indian wheat has a reputation for being full of dirt, but Dr. Voelcker's enquiries showed that most of this dirt does not come from the threshing-floor, but is added afterwards by way of adulteration. On the other hand, no European market would look at the stuff that the cultivator turns out as sugar : his fibres are sometimes so badly prepared that much of their value is lost, and the flavour of his ordinary tobacco is not appreciated even by his richer neighbours. The question of adapting his methods to the tastes of a wider market is of great practical importance, but can hardly be discussed in this place : the best chance appears to be the multiplication of collecting agencies under skilled supervision which shall take over the raw produce and work it up for the market. The great spread of cotton-ginning mills in recent years indicates the direction which this movement may take in future.

Disposal of produce.

The cultivator has usually to dispose of most of his produce as soon as it is harvested. When possible he stores

enough food to last his family till the next crop is ripe and to meet his expenditure on wages ; and he usually keeps his small supply of hemp fibre, a little of his cotton, and so on, but he has to sell a good deal to pay his rent and to get enough money for his miscellaneous expenditure. Sometimes, however, he is heavily in debt, and has to hand over nearly the whole of his produce to his creditor, who then allows him enough to keep his family alive till the next harvest. Cultivators in this position have no interest in the disposal of their crops beyond keeping whatever they can out of their creditor's hands. The man whose produce is in his own hands either sells it to a trader living in his village or takes it to the nearest market; but there are certain crops which are commonly grown under another arrangement, namely, indigo, sugarcane and poppy. The manufacturers of these products are naturally anxious to assure a supply of raw material for the year, and a system has grown up under which they assure themselves by giving advances of money at seed time to cultivators who undertake to supply them with the produce of a certain area at a fixed price. Theoretically this is a good system : the cultivator is assured beforehand of his market and the manufacturer of his raw material, while the former gets a cash advance just when he most needs money, and where the parties can trust each other the system works well in practice. This is seen most conspicuously in the case of poppy, where the advances are given by Government, and in the neighbourhood of some indigo factories held by upright and considerate manufacturers. But where the manufacturer is untrustworthy (as in the case of many of the smaller indigo concerns, and a large number of sugarboilers),

the practical result of the system is evil: the accounts are manipulated against the cultivator, and as soon as he can be shown to be in debt at the end of a season he is forced by threats of legal proceedings to grow a larger area than he can manage, and often to accept a lower price. He thus falls into the power of the manufacturer, who takes good care to maintain his hold over him.

One practical evil of the system when worked in this way is that it interferes with a proper rotation of crops: thus while the indigo business was prosperous, indigo was sown far too often in many fields, and the soil injured in consequence: so, too, there are parts of Rohilkhand where the land is forced under sugarcane so frequently that it has become impoverished; the cultivator is bound to grow a certain area, for he is ordered to do so by the manufacturer who is his creditor, and as he cannot enlarge his holding he must use some of his land that bore the same crop quite recently, when, if he were a free agent, he would certainly grow something else. It is a remarkable fact that the recent decline in the cultivation of indigo, due to the fall in the price of the dye, is a source of intense satisfaction in many villages that formerly put a large area under this crop.

The necessity for the prompt sale of produce is undoubtedly an evil. Just after harvest so many cultivators are in a hurry to sell that the buyers are able to lower prices, and the seller loses accordingly; had he enough capital to enable him to hold his produce for a few weeks, he could get substantially higher prices. But this evil is not confined to these provinces but is to be found wherever small holdings are common, and even in some places where holdings are large;

and it can be avoided only by the growth in wealth of the people generally.

Payment of rent.

As we have indicated above one great cause of early sales is the need for paying rent; the landholder is usually in as great a hurry for cash as the cultivator. In most parts of the provinces rents are calculated and paid in cash, and may vary from one rupee an acre for the worst bhur and the more precarious ricefields to from twelve to fifteen rupees for the rich goind round villages, and to as much as fifty rupees for market-gardens near the larger cities. The rents of course depend largely on the competition for land; in tracts such as Bundelkhand and the unhealthy Tarai, they represent a much lower share of the produce than in the central and eastern districts, where every patch of fertile land has many claimants, and the difference between the two cases is seen not only in the amount which the landholder asks for but in the amount with which he is contented. Where tenants can be found easily, a man who does not pay promptly can be got rid of and replaced by a more satisfactory tenant, but in the backward tracts the land is waiting for cultivators and ejectment is very rare; hence the tenants pay on the whole a much lower proportion of the demand than in the districts that are thickly populated; they claim more consideration for any accidental injury to the crops, and if the landholder insists on full payment, they are apt to leave the rent unpaid, throw up their holdings and take fresh land in a neighbouring village. Thus the real pressure of rent in such tract is even less than is suggested by the amount demanded, which is in fact an ideal only to be realised in the best of seasons.

Cash rents are however not universal. In some large tracts, and numerous smaller areas, the rent is calculated by some system that makes it depend on the amount of the produce. These systems are usually found where the produce is precarious: the landholder has then to share the risk of loss in order to get the land cultivated. The simplest of these systems is actual division of the produce (*batai*), the grain on the threshing-floor is weighed and the landholder's share handed over to him, the share varying from one-half to one-fourth or even less according to the risk involved in cultivation and the strength of the tenant's position. The drawback to this system from the landholder's point of view is the risk of fraud: the risk is least where he lives in the village and collects his own rent, while when he lives at a distance and employs an agent, his share is often considerably reduced before it reaches him. A variation of the system more favourable to the landholder is the method known as *kankut*, under which the amount of the standing crop is estimated and the landholder's share valued at a fixed rate, the value being payable in cash. Here, too, the landholder is liable to be cheated in the estimation, but, on the other hand, he is often able to insist on a rate much more favourable to himself than he would get if he took the produce to market.

These are the commonest systems of calculating rent; the others are much localised and need not detain us, though we may mention that in which the rent of a field varies from year to year with the nature of the crops sown on it, a plan that looks cumbrous but is apparently suitable to the tracts where it is to be found. In all cases, except that of actual division of produce, the cultivator is forced

to sell soon after harvest to pay his rent ; and even where produce is divided, the landholder is apt to sell his share at once, so that the objectionable flooding of the market is not appreciably reduced.

Note to Chapter IX.

The rental systems prevailing in the provinces can best be studied in the earlier settlement reports ; there seems to be no work dealing with this interesting subject as a whole.

CHAPTER X.

PLANT DISEASES AND PESTS.

Growing crops are exposed to injury from an immense variety of living things ; we may conveniently classify the living enemies of crops as either animals, insects, fungi or weeds, and we may say roughly that the smaller the individual enemy, the more numerous it is and the greater injury does it cause.

Animal pests.

Among animal pests there is, first man, who steals the melons, the maize cobs and the fruit, and occasionally reaps part of some one else's field. Then there are the cattle, which are apt in their hunt for food to graze on the growing crops ; and the monkeys, which religious sentiment allows to congregate in such numbers that they do a great deal of damage in the fields. Of wild animals, pig are probably the worst : they live usually in the lowlands, but come into the cultivated ground at night hunting for the roots which constitute their favourite food, and do much harm by rooting and digging among the crops. Deer feed on growing crops, and do nearly as much damage with their feet as with their teeth : jackals make a speciality

of maize, pulling off the cobs, and also eat sugarcane: porcupines dig up seed potatoes and other root crops, and in some places are ruinous to young trees; rats construct extensive burrows in the fields, and sometimes cause considerable loss by eating the produce or by storing it in their burrows; squirrels and numerous birds pick the ripe grains out of the crops; and in fact there is hardly an animal that has not to be guarded against.

Remedies.

Watching is the great preventive of all attacks of animals; for the fields are almost universally unfenced and the country is so open that they can go where they like. As soon as the crop comes to a dangerous stage, a shelter is put up in the field, often raised high above the ground, and the members of the family take it in turns (sometimes with assistance from labourers who are past other work) to occupy these shelters, scare away the birds and animals, and keep a look-out for thieves. Where wild animals are numerous, some one in the village often possesses an ancient gun, which is fired occasionally rather to frighten than with any intention of killing; and the liberal grant of licenses for such guns is the only way of helping the people living near forests or riverside jungles, care being of course taken that the guns are such as to be unfit for use by criminals.

Monkeys cannot be killed or injured, as they are sacred; but when they increase so much as to become an intolerable nuisance, an expert is occasionally hired to trap them and take them away to an island or let them loose on the far bank of a river.

For field rats the most effective remedy is to irrigate the field, drowning some and driving the rest to shift their quarters. Musahars or men of some equally low caste are occasionally employed to catch the rats, but when a field is badly infested, nothing but a thorough flooding seems to have much result.

Fencing.

It has often been suggested that the damage caused by the larger animals could be prevented, or at least much reduced, by fencing the fields, but there are insuperable objections to the general adoption of this course. Fencing with wood is useless because the weather and the white-ants between them destroy the fence in a very short time, and much of it is soon stolen for fuel, while wire fences with the necessary gates would cost as much as the fields they protected, and could not possibly be bought by the cultivator. Live hedges could be planted between the fields, but they require a great deal of space, as crops will not grow satisfactorily within four feet of a hedge, the established roots of which take up all the water that the soil contains. Now the field boundaries are barely a foot wide and serve as paths and water-channels ; if hedges were planted on them the amount of land rendered unproductive would be a greater loss than any animals would cause.*

Hedges and fences then are out of the question for general use, but fences are made in exceptional cases: in the eastern districts a low mud wall is often built round a cane field ; thorns are put round vegetable fields, and along the borders of paths frequented by cattle, and so on. In

* In a square field one bigah in area the hedges would probably render one-tenth of the area quite unproductive.

Bundelkhand there is sometimes a fence round the manured homeland (gauhan) of the village. A common device is to border a field with a crop on which animals will not feed: san-hemp is often planted this way in the kharif and linseed in the rabi. So, too, the outer plants in a cane field are sometimes twisted together so as to give the appearance of a fence, while in some cases worn-out fishing nets or similar obstructions are placed across paths frequented by deer.

There may be cases in which a large landholder, or a group of landholders, would find it profitable to construct a fence along the edge of a forest so as to keep animals off a large area of cultivated land. Some years ago Government fenced in this way part of the Agra district which was going out of cultivation owing to the inroads of wild cattle from an adjoining state: the operation is however very costly and can be recommended only in exceptional cases.

Birds.

It is important to know that all the birds seen in the fields are not enemies. Those which live exclusively on seeds or fruit are enemies as a rule, but those that live on insects are indispensable to the farmer, and if their numbers are seriously reduced, the insects on which they feed increase to an extent that involves enormous loss; all insect-eating birds should therefore be protected and encouraged in any way that may be possible.

Insects.

This brings us to the second class of pests—the insect. Not all insects are obnoxious, for, as we have seen in a previous chapter, some of them are indispensable to the proper fertilization of the plants, and there are some that live on other injurious insects, but the number of insect

pests is very great. They have not all been studied in detail, and all that we propose to do is to describe a few of the commonest and most injurious. (1) Many *caterpillars* do a great deal of harm by eating the leaves off the growing plants or boring into the unripe seed pods and eating the seed. The commonest perhaps is the one known commonly as *Chheda*, which is to be found attacking the pods of gram, peas and arhar at the end of a wet cold weather. His ravages are not very obvious while the crop is on the ground, but when the pods are opened the seed is missing, and what looks like a good crop may give a very poor outturn. There are numerous other caterpillars, nearly all of which seem to thrive in wet weather. (2) The *borers* do some harm to juar, but sugarcane suffers most from them. Certain moths lay their eggs on the young cane plant, and the grubs coming out of the eggs bore into the shoots and settle down there, feeding on the nutritive material which the plant is building up for its own use. The shoots affected usually die, and in any case no sugar is to be found in them. All is not yet known about this class of pest, but apparently they are carried over from crop to crop in some cases at least, in the seed canes, and it is important to see that the canes or portions of cane saved for seed are not affected, as half the produce of a field may easily be lost through their ravages. The borers are known by various names in different places, *Ar*, *Dhola* and *Ghirai* being perhaps the commonest.

(3) Plant lice (aphis) are another common pest; they are familiar on rose trees and other garden plants, and in the field are commonest on rape or mustard. When the weather has been damp in January or February every plant

of rape in a field may be seen swarming with these small, green insects : they suck the sap out of the plant, and thus abstract the material that should go to form the seeds. This aphis is usually known as *mahun*.

(4) With these may be compared the rice sapper (known as *gandhi*), an evil-smelling fly that settles on the stems of the rice plants and sucks the sap out of them.

(5) In the same way a sort of fly attacks the buds of the mango tree in damp cold weathers. The attack may be detected by the shining, sticky stuff that exudes over flowers ; this is the sap running out through the hole bored by the pest, and where it has escaped hardly any fruit sets.

Regarding almost all the insects that come under the foregoing types, it may be said that their attacks cannot be entirely prevented by any means within the reach of the cultivator. They all multiply very quickly in favourable circumstances, so that their ravages can be reduced to some extent if the first that appear are carefully picked off the plants and drowned or burned ; but this is at best a partial remedy, and when the insects are either hard to see or too alert to be caught with the hand, it is little or no use. In other countries such pests are attacked by spraying some poisonous liquid over the crops affected. Cultivators cannot adopt this course unassisted, but it might pay a landholder exceedingly well to keep a few of the simple syringes used for spraying and to lend them out, along with a supply of the liquid, to cultivators whose fields might be suffering.

White ants.

Three other insects may be mentioned which in their various ways do a good deal of harm, white ants, locusts,

and weevils. The familiar white ant (*dimak*) is to be found almost everywhere in the ground; usually it lives on dead matter, but in some places it attacks the seed when placed in the ground and eats off the young root as soon as it forms. The injury is seldom serious in the case of most crops, though the number of wheat plants that mature in a field may be appreciately reduced; but cane suffers greatly if the pieces put in the ground for seed are attacked. There is apparently no effective remedy: cultivators sometimes trap some of the white ants in a cane field by burying cow-dung at the corners; the insects swarm into this, and when it is full of them it is taken out and burnt, but this is at best a palliative.

Locusts.

Locusts appear to breed in very few parts of the provinces, but from time to time they pass over us in enormous swarms from their breeding grounds in Rajputana or further west. Where they settle they devour every green leaf and shoot, and may cause great loss in a limited area. It is usual to frighten them away by noise when they seem inclined to settle: if they persist, the best way of mitigating the loss is to drive them into trenches containing some water. Should they be allowed to breed, the next generation will do enormous damage, so that it becomes necessary to gather by hand the eggs which they have deposited in the ground.

Weevils.

Weevils (*ghun*) are small grubs that attack many kinds of grain when stored, especially during the monsoon; they eat all that is worth keeping and leave only an empty husk.

Cultivators who store their own grain manage usually, but not invariably, to avoid loss, but grain-dealers sometimes lose a great deal in this way. Where regular store houses of masonry are not available, the best course seems to be to plaster the inside of the receptacle thickly with cowdung and line it with *bhusa ;* further, it is advisable to store the grain in several receptacles rather than all in one, as weevils spread very fast. Small quantities of grain required for seed can be preserved in an ordinary *ghara* with a clay saucer cemented over the mouth ; and in all cases it is the rule that grain stores should not be opened during the monsoon.

Fungi.

The third class of pests is the *fungi*. A fungus is a group of very small living beings, which cannot (like ordinary plants) draw their food from the air and soil, but require it ready made. Some of them have acquired the habit of living inside other plants and feeding on the materials which the plant has prepared for its own consumption, the result being that the plant cannot fill its seeds with food-materials, or in other words, that the outturn of the crop is greatly reduced. There are enormous numbers of these fungi, but the only species that do great and common injury in these provinces are those known as *rusts* (in vernacular *ratua* or *girwi*). There are many rusts : two or three (at least) are known on wheat, others on barley and others on linseed ; their appearances differ in detail, but they can usually be recognised by yellow, red or dark spots or streaks formed on the leaves or stems. They may be observed in almost any field and any season, but as a rule they do not multiply enough to

cause serious loss. Damp cloudy weather, however, enables them to spread with enormous rapidity, and where the dampness of the air continues for some time in January and February, very serious damage must be expected.

To take wheat as an example. In January small red or yellow spots may be noticed here and there on the leaves of a few plants in a wheat-field: let damp weather set in and the number of these spots will increase very quickly, so that the whole crop looked at from the ground-level has a colour like iron-rust, and in places the ground itself is coloured with a rusty powder. This means that the fungus is living *inside the plants*, and the rusty powder consists of what are called the *spores*, being parts of the fungus (analogous to seeds) which separate off from it and can start a new life. When the attack is bad, it extends to all parts of the plant; later, long black streaks will be seen on the stems, while if the ears are examined it will be found that the grain is shrunken or shrivelled, or even in the worst years that there is only a small black speck where the grain should be. In such cases the appearance of the growing crop may be most deceptive, for the damp weather will have made the plants grow high and thick, and an inexperienced observer may think there is an excellent yield if he does not take the trouble to look inside the ears.

These rusts have not been fully studied; probably what we have just described in a wheat field is the joint work of two or three different species, all living on the plant; but enough is known to enable us to say with some confidence that no remedy can be applied. To what extent the attack can be prevented or avoided is a question to which we will return.

Weeds.

Lastly there are weeds. It is common knowledge that innumerable plants spring up of themselves on any piece of land that is not hopelessly barren, and the cultivator regards any plant in his field as a weed if he does not want it. The seeds of plants are present everywhere : many are carried about by the wind, some by water, some by birds and animals, while many lie where they have fallen from the plant. Where the cultivator makes a seed-bed to start his crop, he cannot help making a seed-bed for many of the other seeds that are present, and they germinate along with what was sown. Hence follows the necessity of weeding, as otherwise the weeds would compete with the crop sown for light and air, for water and plant food, and might smother it altogether. These common weeds, however, are not a very serious evil so long as they are taken off the land before they drop their seed ; in fact the cultivator uses some of them for vegetables and gives many of them to his cattle ; the serious danger is that a plant with a very large root system may establish itself in land and hinder cultivation.

A good instance of this is the weed *baisurai* which is found in a few localities in these provinces, especially near Jaunpur and in the east of the Muttra district. This plant has roots of exceptional depth, so that it can draw water from a low level. If it gets a start during the cold weather, it grows almost into a shrub by July and has to be removed by hand, a very laborious process, before the land can be tilled again. But the best known instance is *kans* grass, one of the plagues of Bundelkhand. Its tough, wiry roots go very deep, and also spread sideways, matting together in

such a way that a plough cannot be driven through them. When then this weed has got hold of a field, the cultivator is almost helpless, and in Bundelkhand he lets the field alone till the weed has worn itself out, a matter of ten to twenty years. The weed can, it is said, be killed by repeated flooding, but water is not to be had where it is commonest, and no other remedy is known at present. These are the only two weeds that affect seriously large areas of the provinces, though there is no doubt that many others would give great trouble if the fields were not weeded with the minute care they receive.

General remarks.

We have indicated above that the seeds of innumerable weeds are present everywhere, waiting for a chance to spring up : a similar remark is true also of fungi and of insects, and it must be realised clearly if we want to see the exact position of the cultivator in regard to these pests. As a matter of fact, the cultivator is not in the same position as a mechanic or other workman. A mechanic takes the materials he needs and makes what he wants out of them, and he need not be afraid that his materials will produce other things of their own accord ; a carpenter making a box is not liable to find that his wood and nails have used themselves to produce something quite different. But this is very nearly the position of the cultivator. His materials are the light and air, water, and the plant food in the soil : he may arrange them to the best of his ability to grow a crop of wheat and find that he has got a crop of weeds instead : or having got his wheat to grow he may get no benefit of it, because the spores of rust were among his materials and

the weather has given them a chance to multiply, and to absorb the plant food which was intended to form the grain.

Speaking generally, the plants or insects that we can see living on a square yard of land at any moment are very far from showing its capacities. There are probably hundreds of seeds, and thousands of spores lying in the ground, because the weather conditions do not give them a chance to grow: change those conditions by ever so little, and some of the seeds or spores may spring into vigorous life and reproduce themselves so rapidly that in a very short time the whole character of the life present in plot has changed. So, again, all kinds of insects are to be found in small numbers: but a change in the weather may start some particular insects multiplying at an enormous rate. We do not know in detail all the causes which affect the numbers of these pests, but we know in a general way that a very slight divergence from ordinary conditions is sufficient to make an enormous alteration in their numbers. When then we hear suddenly, as in 1899, of armies of caterpillars marching over the young rice fields and clearing the plants off the ground, it is not correct to regard this as something portentous, or indicative of divine displeasure: the occurrence is unusual of course, but it is to be expected in the circumstances. In ordinary times these caterpilliars, like all other living things, have to struggle hard for life: they have to find their food and to avoid becoming food for other beings. Thus out of the enormous numbers that are born, very few indeed live long enough to breed. But with a slight change in conditions they may get their food much more easily, or, on the other hand, their enemies may be

hampered in their pursuit, when the enormous speed at which they multiply unchecked gives the idea that they are an entirely new phenomenon. As we have said already, the cultivator is more or less helpless in the presence of most of these small enemies : but at least he knows when to expect them, because past experience has taught him that given certain conditions the insects or the fungi appear of themselves.

There are, however, two practical consequences that follow from considerations such as the foregoing. In the first place whenever the attempt is made to grow a new crop in any locality, we must always be prepared to find that the new crop is specially suitable to some insect or another that has hitherto done little harm : if so, that insect will multiply with extraordinary speed and will destroy the exotic variety. The second consideration is that it may in some cases be possible to avoid the loss caused by a fungus or insect by growing a variety of the crop which (for whatever reason) the fungus or insect cannot live on. An excellent instance of this is found in the history of the sugarcane in these provinces. Some years ago a valuable variety of cane, known as *agaul*, was found to be most susceptible to a fungus known as *lawahi*, and by other names. For a few years the people suffered great loss from this fungus, which may make a field entirely worthless ; then they began to grow other varieties of cane which did not suffer in the same way. We do not know, nor does the cultivator know, exactly why some varieties suit the fungus and others do not, but for practical purposes the fact is sufficient. There is some hope that other fungus-diseases, notably wheat-rust, may be

avoided in the same way by finding varieties that are not liable to the disease.

Note to Chapter X.

A good general view of diseases and pests will be found in Disease in Plants, by Dr. Marshall Ward (London, Macmillan). Plain descriptions of the commoner pests will be found in the Entomological circulars issued from time to time by the Indian Museum.

CHAPTER XI.

CATTLE AND OTHER FARM ANIMALS.

Supply of Cattle.

Practically all the heavy work of the country,—ploughing, raising water from wells, threshing grain and carrying produce,—is done by cattle: buffaloes take some share, especially in ploughing wet rice land and in carting, but most important of all is the bullock. In the greater part of the provinces the cultivators do not rear bullocks for use on their land; it is of course the ambition of most men to keep a cow for the sake of the milk, and the bull-calves born in the village are usually kept till fit for work and then put to the plough, but most of the cattle used are brought from outside. There are two great breeding grounds in the provinces, Bundelkhand on the south and the submontane districts on the north. In both of these tracts the population is scanty and there is a great deal of uncultivated land, the rough grazing on which is sufficient to rear large numbers of young animals. When these are ready for work they are brought in droves into the more populous districts and sold either at fairs or from village to village. Speaking roughly, the submontane tracts supply most of the cattle imported into Oudh and Rohilkhand, while Bundelkhand finds its chief market in the lower duab and parts of Benares.

The extreme east of the provinces is supplied from Bengal, while on the west the rich districts of the upper duab get their large and powerful cattle mainly from the Punjab, and parts of the middle duab depend largely on the produce of Central India or Rajputana.

Causes of Importation.

At first sight it appears unsatisfactory that the country should not provide the cattle it requires, but the question is rather complicated. If young stock are to grow up strong and healthy, they need not only an adequate supply of food, but also plenty of space; and speaking generally they are better fitted for hard work if they have had to find their food or most of it for themselves. But as we shall see later on the supply of grazing land is limited in the more populous districts, and, as a matter of fact, the home-reared animals are usually much inferior to those that are imported, so that from the economic point of view there is a good deal to be said for the present practice. It is always a good thing to give owners of cows a chance of having them served by a really good bull, but under present conditions it would be unreasonable to expect that the practice of importation should disappear or be largely reduced.

Local Breeds.

As a rule little attention is paid to the choice of a bull for the cows kept in the provinces; they are covered either by a bull taken from work or by one of the sacred animals which are from time to time set free by pious Hindus, and wander over the country feeding at will and choosing their own mates. The result is that there are very few recognis-

able breeds in the populous districts, since a breed means the produce of parents chosen for particular characteristics. In the breeding tracts, on the other hand, endeavours are made to keep the breeds more or less "true to type," a phrase which means that all animals of the breed shall have to a large extent the same characteristics. What these characteristics should be depends on what the cattle have to do: * a breed may be noted for its size and strength, for its quickness of movement, for the quantity and value of the milk given by the cows, and so on. In the greater part of the provinces the requirements of the cultivators are chiefly ability to stand hard work, and subject to this speed of movement: these characters are possessed to an exceptional degree by some of the breeds in the submontane tract, notably that which is found about Khairigarh in the Kheri district; while the common type of Bundelkhand cattle is marked by its power of getting through a very fair amount of work on very poor food.

Cost of Cattle.

But with the smaller cultivators cheapness is the paramount consideration, as they cannot command the capital required to purchase larger animals: in the upper duab Rs. 150 is not at all an uncommon price for a pair of plough-cattle, and for this sum the cultivator can get large and powerful animals from the Punjab, but in the east of the provinces

* Readers whose ideas of what constitutes a "good" breed have been derived from English experience may be warned against applying that experience in India. English cattle are bred to produce beef and milk, while Indian cattle are wanted to work; and the qualities required in working cattle are entirely different from those which result in a large production of beef.

the price seldom exceeds Rs. 50 and falls as low as Rs. 25—a sum which will purchase only the poorest type of animal. The man who spends a large sum on his cattle is likely to take great care of them, to feed and house them well and to avoid overworking them as far as possible, while the man who can only buy the cheapest animals is usually unable to feed or house them as they require, and the necessities of his own existence make overwork a frequent occurrence; hence the wretched condition of so many of the cattle in the districts where holdings are smallest and the people poorest.

Food.

Animals are made up of precisely the same elementary substances as plants, though they require to consume these substances in different forms, and convert them into such things as skin, bones and muscles, not leaves, flowers or seed. We have seen in an earlier chapter that the most important products of plants from the nutritive point of view are (1) starch and the various sugars, and (2) the proteids; when speaking of animals it is more convenient to call these respectively work-food and flesh-food. The first class supply energy which enables an animal to go on working, but the second class (which it will be remembered contain nitrogen) are essential to replace the wear and tear of subtance that is constantly going on in an animal body: in order to feed an animal so as to get the best work out of it, it is necessary not only to see that the weight of food given is sufficient, but also that it contains a due proportion of flesh-food. Now we have seen that most of the flesh-food produced by plants is stored in the seeds and very little of

it in the leaves and stems: it follows that when cattle are doing hard work they ought to receive a fair amount of seed or grain as well as fodder, and even when they are idle some grain should be given to keep them in really good health. In the west, where the cattle are expensive, this is recognised by the cultivators, and the cattle, which are kept tied in the cattle-house when they are not working or at exercise, get a ration of gram or some other cheap food-grain, or of oilcake, which consists of the seed after most of the oil has been removed. But further east, where holdings are small and the cattle poor, the cultivator—who must feed his family first—can at most give his cattle a small supply of grain when their work is hardest, usually when raising water from wells, and the rest of their time they have to do as best they can on the dry fodder he is able to give them, supplemented by what they can pick up when turned out to graze.

The bulk of the food of cattle comes from the parts of plants which are not required for human consumption: from November till April it is the chopped stems of juar and bajra, or the trodden plants of the autumn pulses: while from May to October it is the trodden plants of the rabi crops. But in all cases almost this supply has to be supplemented in one way or another. In the west crops are grown specially for fodder, which is cut while green and given to cattle: in the east the cattle have to look for some part of their food on the waste and barren land that is included in the village. During the rains and the early cold weather, all but the very worst barren land bears a crop of grass which, though not very nutritive, suffices to keep the cattle in tolerable health; but in the season from January to June

the ground has been eaten bare and there is nothing on it except a few scattered tufts of grass or other plants which have to be searched for over a wide area, and at this season the condition of the cattle is miserable in the extreme. Whether more use can be made of the waste and barren lands as grazing grounds is a question that has been studied for many years, but so far with no results of practical value.

Fodder famines.

It will be readily understood that as so much of the food of the cattle is dependent on the crops, any failure of these must have a disastrous effect. On the whole, a fodder famine is the worst calamity that can befall the people : it does not necessarily come whenever there is a food famine, because it may happen, as in 1896, that the kharif crops grow large enough to give a supply of fodder, though yielding little or no grain, but in the case of a complete failure of the rains it seems to be inevitable. The emergency cannot be met by the individual cultivator to any great extent: some men will send off their cattle to graze in the lowlands or in the forests, if not too far off: some will make shift to raise fodder crops on their irrigated land, though in most cases this has to be devoted first of all to producing food for the family : but the majority are helpless, and large numbers of cattle must die either from sheer starvation or from illness brought on by inadequate or unsuitable food. Then it may happen that when rain comes and the land can be ploughed there are not enough cattle to do the work. The organisation of the fodder supply in such seasons is a problem that has to be faced by Government, but it does not seem likely that the problem will ever be completely solved, and at the end

of a famine there will always be the need for supplying cattle to cultivators who would otherwise be unable to plough their land : this is of course primarily the duty of the landholder, whose direct interest requires that his land should not lie fallow, but his efforts have, as a rule, to be supplemented by Government as well as by charitable funds, which indeed can be expended in no more profitable manner. The experience of serious fodder famines in these provinces is fortunately very scanty ; the last was in 1877.

Water.

Cattle need considerable quantities of water, and the most satisfactory way of supplying them is from a tank dug near the village and kept full from the canal ; the cattle can be driven to the tank and can drink as much as they want. Where, however, the village is not served by a canal, the tanks are apt to be dry for a large part of the year, or to contain only a little impure water : where this is the case water must be drawn from the wells. Practically all parts of the provinces have sufficient wells for the supply of drinking water for the cattle as well as for the people, so that so far as can be judged from past experience there is no danger of a general water famine.

Shelter.

Cattle also need shelter from the heat and cold. The expensive cattle get this, being usually housed in mud-walled enclosures with thatch roofs, and occasionally in the western districts getting some litter (usually sugarcane leaves) on which to lie during the coldest part of the year ; but as we go east the use of litter becomes unknown, the enclosures

become rarer, and the cattle are often tied in an open space, and sometimes without even a roof. The loss resulting from this practice is at least threefold: to begin with, the extremes of temperature affect the animals' general health very much as they might affect a man, and they are not in a position to work their best: secondly, there is an actual waste of food: and thirdly there is a loss of manure. We have already discussed the manure question, but the loss of food may be noticed briefly. What we have called work-food is used up in the body partly in maintaining it at a constant heat; we know by experience that the temperature of the human body remains constant whether the air is hot or cold, any divergence from the ordinary temperature being a sign of sickness, which the doctor looks for with his thermometer; and we know from our own experience that we want more food in winter than in summer. The reason of this is that more food is used up in keeping the body warm; from this point of view the food is like fuel which is burnt to produce heat. There is no difference in this respect between man and animals, and the colder an animal is the greater the quantity of food that it uses up in maintaining its temperature, and consequently the less remains to enable it to do work. Exposure to a cold wind means that an animal's skin is being constantly cooled on the outside and being constantly supplied with more heat from within, so that it is a waste of food to expose an animal unnecessarily.

Exercise.

In order then to keep working cattle healthy, the points to be attended to are to give them a sufficient supply of

water and of nourishing food, and to shelter them when a rest. Further, they should have regular exercise, and when they are not required for work they should be sent out to graze: and overwork must be avoided wherever possible. If these conditions can be secured, the best value will be obtained from the cattle provided they escape from epidemic disease.

Disease.

There are three common kinds of epidemics, known as rinderpest, anthrax and foot-and-mouth disease. Their symptoms are not easily described, but the people know them well by experience: anthrax is generally fatal, but it is much rarer than the other two; rinderpest is the worst of the three as it is very common, spreads rapidly and kills most of the cattle affected, while with foot-and-mouth disease the number of losses in the provinces is small, but the disease weakens the cattle for a time if not permanently. In all three diseases, medical treatment is of comparatively little use; careful nursing may of course save an animal here and there, but, as a rule, the disease runs its course, and the great aim of the cattle-owner is to prevent his animals being exposed to infection. Until the last few years the only way of protecting them was to isolate them entirely from all other cattle immediately the disease was known to be in the neighbourhood: it was necessary to keep them tied up at home and supply them with fodder and water, for if they were to go out to graze, or to the tank to get water, there was every danger of infection, and even a chance encounter with other cattle in a street might have fatal results. Such precautions were and still are of the

greatest value, but they cannot ensure absolute protection ; even a man who takes every precaution in a cholera epidemic cannot be certain of escaping the disease, and with cattle the channels of infection are less certainly known and the risks are correspondingly greater. Further, a poor man who ties his cattle on the roadside, and has no fodder in store, cannot segregate them effectively, while cases have been known where the village leather-workers (who are by custom entitled to the hides of animals dying in the village) have introduced rinderpest into the stalls of large cattle-owners in order to increase the amount of their perquisites. The existence of this dastardly practice would be incredible if we did not know that in some localities cattle are frequently poisoned by the same classes and with the same object. Landholders can easily protect their village against the disease being intentionally spread if they insist that the carcases of all animals dying of infectious diseases shall be burnt and no part of them given to the village menials : if wood for burning is not available, dried dung can be substituted, a layer being placed under the carcase and more piled up round it.

Protective inoculation.

Within the last few years systems of protective inoculation have been devised for both rinderpest and anthrax which will rob these diseases of their terrors if the people will accept them. A small quantity of a watery fluid is injected in the animal to be protected, and the effect lasts for a considerable time, certainly for long enough to allow the epidemic to wear out. The cattle need not be isolated after the treatment ; indeed it is recommended that they should

be allowed to run free, for if by doing so they get the disease, they get it in a very mild form which may protect them against another attack at a later period. The prospects in these provinces of this system of inoculation, the first fruits of applying the highest scientific knowledge to the agriculture of the country, are still uncertain : the people as a rule are not actively opposed to it though they are inclined to regard it as a suspicious novelty, and any active steps taken by Government officers would probably convert this suspicion into overt hostility. The policy of Government is therefore to provide every facility for inoculation, but to leave it entirely to the people to decide whether it shall be practised : and it is for the landholders to lead the way in inducing their tenants to adopt this method of protection ; if they do so, they will enrich their tenants and benefit their estates accordingly.

Dairy produce.

We may now notice briefly the dairy products obtained by the people of these provinces. We have seen that when a plant forms seeds it provides for the new plant a store of food sufficient to nourish it till it is able to maintain an independent existence. In exactly the same manner animals provide for the nourishment of their young : in some cases as with birds the nourishment is stored up along with the embryo, so that an egg is directly analogous to a seed, but with animals, such as cattle, the provision is not supplied all at once but is offered as required in the form of milk. Now, as milk is produced with the object of feeding the calf, it naturally contains the same sort of things as are found in seeds ; there is a form of sugar (which a young

animal can digest more easily than starch), there is fat, and there are proteids. And just as man appropriates the store of food in seeds, so he takes the milk for his own uses, leaving only a small share for the calf and training it to find food for itself earlier than it would otherwise do. Milk then is an exceedingly valuable food, particularly for children, and as we have said almost every family is ambitious of possessing a cow. Not only is the milk consumed in its original form, but the different substances which it contains are extracted for separate consumption. Thus in Europe the fat is extracted in the form of butter and the proteids in the form of cheese: in India different processes are followed and the final products differ accordingly. Butter is little used owing to the great difficulty of keeping it without deterioration, so that immediately after extraction it is heated and clarified, and the resulting product is known as *ghi*,* which is used universally by the better classes for cooking purposes and which is exported in considerable quantities to the cities of Bombay and Calcutta. The proteids are usually extracted in the form of curds: milk is readily attacked by a large number of bacteria which produce various kinds of fermentations, leading to different results, and as the result of one of these fermentations the proteids separate out in a more or less solid mass known as *dahi* or curds, and greatly relished by the people.

The amount of milk, and also the proportion of nutritive substances which it contains, depends partly on the breed or individual and partly on the feeding. There are great

* Butter is readily attacked by certain bacteria and converted into an evil-smelling substance; this danger is averted in the case of *ghi* by the repeated heating which is part of the process of manufacture, as the heat destroys any bacteria that may be present.

differences between individual cows of the same breed, and the cows of one breed differ widely from each other: there is no well-known milking breed in these provinces, and the better classes get their cows from the west, where this character has been developed, but the poorer cultivators have to content themselves with an ordinary cow of the locality which gives a small quantity of very poor milk. But the best cow will give poor milk if she be not properly fed: the large quantities of food materials found in the milk can be derived only from the food which the cow has received, and in particular as the milk is very rich in proteids the cow requires a large supply of flesh-food, that is to say, either grain or oil-cake. Thus with cows as with working cattle good food is necessary if they are to give the best return to their owner.

It is worth knowing that the ordinary buffalo gives more milk than the cow, and it is believed to be on the whole richer. The best milkers that can be got in these provinces are the enormous Hissar buffaloes imported from the Punjab.

Sheep.

The other animals with which we are concerned require only a brief notice. Sheep are kept partly for their meat and partly for their wool: unless specially fed up for the butcher they do not get any food except what they can pick up when feeding on the roadsides or waste land, or gleaning in the fields after harvest. They eat such small plants that they can find food where cattle would starve, and as their dung and urine are both of great value as manure, they are often kept on fields after harvest where they eat the weeds and stubble, and incidentally enrich the soil by their drop-

pings. Their wool is worked up into blankets and other coarse native stuff; it is of the very poorest quality, as might be inferred from the way in which they are fed and from the warmth of the climate. For good classes of wool it is necessary to go to the hills, where the grazing is richer and the climate colder, so that the sheep are in a position to grow good wool and at the same time require it as a protection.

Goats.

Goats are valuable partly for their meat, which is relished by Muhammadans, and partly for their milk: they are in fact the poor man's cow. They can pick up a living off almost any sort of vegetation, but they appear to prefer the younger shoots and leaves of trees, and for this reason they are the greatest enemy of the tree-planter; but they are useful animals to their owners as they turn all kinds of waste vegetable matter into food for human beings.

Pigs.

Pigs are kept only by a few of the lowest castes, and are generally regarded as a pollution; they feed on all the refuse about the village as well as on roots and anything they can get hold of, and they leave behind them nearly as much dirt as they consume. High-caste cultivators are often anxious to have the pigs kept out of the village by the authority of the law: they have the remedy in their own hands, for the pigs come among the houses to search for food, and if the site is kept clean, as it should be, the pigs will go elsewhere. There is a regular market for pigs' bristles, which are used in brush-making, while their flesh is relished by their owners.

Poultry.

Poultry too are unclean to nearly all Hindus, and are kept only by the lowest classes: they have as a rule to find their own food, and their produce, both meat and eggs, is of the most wretched type. Really good poultry can be reared in this country, as may be seen where Europeans have taken the matter in hand, but the uncleanness (in the technical sense) of the occupation makes it very unlikely that a general improvement will take place in the produce.

CHAPTER XII.

MANAGEMENT OF A HOLDING.

Custom of the country.

We have now to enquire the principles on which an ordinary cultivator manages his holding. His objects are first to secure enough food for his family and his cattle: secondly, to have enough produce to sell to pay his rent and other cash expenses of the household, and if possible to put something by; and to grow for himself such necessaries other than food and such comforts and luxuries as his holding can yield; he must also endeavour to manage his holding in such a way that the productiveness of the land is not diminished. Now considering the variety of soils and of possible crops, this looks like a very complicated problem, and it is fortunate that the individual cultivator has not to face it without some guidance. The question has been attacked by many generations of cultivators and their accumulated experience is to be found in the *custom of the country* which guides the individual on such questions as what crops can be safely grown on what soils, what crops

will repay irrigation, what is the best means of distributing manure over the holding, in what order should crops be grown, and so on. This custom of the country is not an infallible guide to the most profitable utilisation of the holding : the best course may never have been tried or may have been discarded through some mischance, or changes in the level of prices or in the demand for particular products may make some changes in the custom desirable ; but it is usually a safe guide to making a living, and the ordinary cultivator is well advised in following it rather than applying his limited intellect to working out a solution afresh. It is true that this adherence to custom may delay the introduction of desirable improvements, but it must also be remembered that the cultivator cannot afford to risk much in experiment ; and among the better cultivators there are usually to be found men who will depart from custom where they see a reasonable prospect of success. It follows that the student of agriculture in its local aspects must first know the custom of the country and then consider in the light of the principles he has learnt whether that custom is capable of improvement.

Management of a typical holding.

To see how this custom works out in practice, we may take the case of a holding of the ordinary size, say five or six acres, containing different soils. There may be a field of high, sandy land : it cannot be irrigated and it dries so quickly that it would be very risky to sow rabi on it ; this land will usually have a kharif crop. But even in the kharif it is not very productive, for it will suffer from either wet or drought : not very much will be spent on its tillage, and it will usually be sown with cheap crops such

as bajra and mung, which do fairly well on such land at a small expenditure. There may be another field of heavy clay: this will be regularly sown in the kharif with rice, the only crop for which it is really fitted, while if possible some cheap pulse will be sown with rough tillage after the rice has been gathered. The rest of the holding consists, we will suppose, of irrigable loam. One portion of it, however, is so lowlying that it is always more or less flooded in the kharif; this portion will probably be sown regularly with a rabi crop, which may sometimes be wheat and sometimes a mixture of wheat or barley with gram or peas. The rest of the land is suitable for either season and will be divided between the two in such a way that tillage can be effected in the time available. It will not be all under kharif, because there would not be time for tillage: nor will it be all under rabi; partly for the same reason, and partly because the cultivator wants to replenish his food stock as soon as possible in the year. Possibly he will do this in the following way: taking the field nearest his house, he will apply his manure to it and sow maize, which will be followed by some rabi crop: another field he will put under juar, arhar and urd, with some til to supply his house with oil, and a border of hemp to give fibre for well-ropes, etc.; the remaining land will be left for the rabi and (after manuring) sown with wheat along with a border of linseed or some lines of rape seed (to supply more oil). In this way the cultivator would get an early supply of food from his maize, say about the end of August or September: rice in September or October: juar, bajra, urd and mung in November: arhar and whatever cheap rabi crops he had sown in March and April, when he would also have his wheat ready to sell for the

rent: he has probably sold some of his rice or maize to pay part of the rent falling due in November or December.

This is the holding of a cultivator of no special skill: a better man would get in a field of sugarcane or opium, or would manage to save more manure and take two crops in a year off a larger area, but the general principles will be the same: to secure sufficient food, preferably an early supply in the kharif; to have something to sell; to have a good variety of crops; and to arrange so that there may be time to till for all with the single pair of cattle which is all that a holding of this size can support.

Mixed crops.

We must now consider the reasons for mixing several crops together, perhaps the most typical feature of duab agriculture. To begin with, mixing is a sort of insurance against vicissitudes of weather, especially in the kharif. Thus large areas in Oudh are sown with rice and the small millet known as kodon: if the season is wet, the rice flourishes, if dry, the kodon, so that in either case the cultivator is fairly sure of getting something. A similar case is the mixture of coarse rice with juar, rare on high land but frequent in some river valleys. In this case if the river comes down in flood, the juar is spoilt but the rice good: if there are no floods the rice is poor but the juar magnificent. A second reason is to economise tillage: thus it costs no more (apart from the seed) to sow juar and arhar than to sow juar alone, but two crops are obtained instead of one; the juar grows more quickly and the arhar plants grow slowly in its shade, but when the juar is removed the arhar rapidly develops and yields perhaps two-thirds of what it would have given if there

had been no juar. The element of insurance also enters into this case: if the juar is very luxuriant, the arhar will be stunted in its early growth, while if the juar is poor, the arhar will develop much better. Another object is to occupy the whole ground and thus check waste of water by evaporation from the soil: if you look at a well-grown juar-arhar field, you will see that the ground is by no means fully shaded from the sun, and that the rain has beaten its surface more or less firm: here there is a good deal of waste of water by evaporation from the soil. This is prevented by sowing some creeping pulse, such as urd, along with the juar; the urd forms a dense mat on the ground and reduces the amount of evaporation while yielding a certain amount of food. The mixture of bajra and mung already mentioned has the same advantages. Yet another reason is probably to be found in the different habits of the roots of different plants: some plants such as wheat are deep-rooted and draw most of their food from some way below the surface, while others have spreading roots which feed close to the surface. By mixing two crops which feed at different depths, both can thrive without interfering with each other, and the total produce of the land will be increased. But probably the greatest advantage of all is that by the use of these mixtures it is possible to keep up the supply of combined nitrogen in a way that would be inconvenient on small holdings if crops were not mixed. The common crops which afford homes for the bacteria which produce combined nitrogen are in the kharif, arhar, urd, mung, moth, indigo, hemp; and in the rabi, gram, peas, masur. Now the people do not care for a diet of unmixed pulses, and there are physiological reasons for their objec-

tions ; but if in order to maintain the supply of combined nitrogen it were necessary to devote whole fields exclusively to pulses, difficulty would arise on small holdings in maintaining a suitable variety in the food of the people. This difficulty is obviated by the mixing of crops. The most striking feature of this system is that (with one or two exceptions) at least one plant in each mixture is of the pulse type, that is, it increases the supply of combined nitrogen. Thus arhar, urd, etc., are grown largely with juar, bajra and cotton: gram and peas are mixed with barley, gram is mixed with wheat, and so on : in all these cases the common feature is that a suitable variety of produce is obtained while the land is benefited by pulse.

Rotation of crops.

In enumerating the *reasons* for growing mixed crops, it is not meant that the individual cultivator recognises these reasons as such : the method has been developed gradually as the result of experience, and the reasons we have given go to show that experience is not misleading, and to explain its results. Similar considerations apply to the practice which has grown up under which a definite order of cropping is followed on a particular bit of land : this part of agriculture is known as *rotation of crops*. The common rotation is most easily recognised in the medium lands suitable for either kharif or rabi. In the case of these lands the rules followed over the greater part of the provinces are : (*a*) a field should bear a kharif crop in one year and a rabi crop in the next ; (*b*) either the kharif or the rabi crop should be wholly or partially pulse, so that a crop of pulse is grown at least once in two years. Thus a

field may in the first year bear juar, arhar, urd, and in the second year wheat : in the third year it will again bear a kharif crop which may be as before juar, arhar, urd, or some variant such as cotton, arhar, or perhaps juar alone : in the last case it would not be considered proper in ordinary cases to grow wheat in the fourth year : wheat-gram or gram-barley would be preferred.

This simple rotation is of course subject to alteration owing to many causes : we may enumerate the following disturbing factors (1) manuring, (2) special features of soil, (3) locality, (4) special needs of the cultivator. In the heavily manured home lands (gauhan or goind), the normal rotation may be altogether neglected, as the supply of plant food is maintained by manuring : perhaps the strongest case of this is a tract near Farrukhabad, where each field gives every year three crops (maize, potatoes and tobacco), each requiring much combined nitrogen and none contributing to the supply : this is rendered possible by the use of large quantities of poudrette every year. Ordinary gauhan land does not get enough manure to stand such treatment, but at the same time it can usually give two crops a year. Another case where manuring affects the rotation is sugarcane as cultivated in Oudh : this crop is heavily manured, and does not use up all the manure applied ; consequently a crop of wheat is very generally taken the year after the cane has been cut, and thrives on the manure left over in the soil. After the wheat, however, a kharif pulse-mixture usually follows.

To illustrate the effect of special features of soil, we may take the rice lands, where rice is grown every kharif. In such cases it is usual to grow gram or peas in the rabi when

the land is fit for sowing, so that most rice land on the average bears a crop of pulse at least once in three years. The yield of pulse is small, but it costs little beyond the seed, and the cultivators hold (what is certainly true) that the pulse benefits the succeeding rice crop.

Another case of the same kind is to be found in the unirrigated sandy lands which, as has been said above, are only fit for a poor kharif. In this case the same crop is sown year after year, but it is important to notice that that crop is usually a pulse-mixture, so that the treatment of the land is as good as possible under the circumstances.

The influence of locality is seen in the case (given above) of land being so subject to flooding that only rabi can safely be grown on it. In this case again pulse or a pulse-mixture is frequently grown, so that if wheat is sown in one year, the next year's crop will usually be gram or gram-barley. Now there are many localities where kharif crops can be sown in ordinary years, but not after a run of wet seasons, and so we get a partial explanation of the well-known fact that after a few wet years the proportion of rabi to kharif tends to rise.

Finally there are the special needs of the cultivator: after a bad year his supply of food may be so short that he breaks the rotation in order to replenish his stock at the earliest possible moment. In this way after the famine of 1896-7, large areas were sown with maize and the early millets which would in ordinary years have been left till the rabi, and the same cause is at work though less obviously in individual cases during most seasons.

Double-cropping.

It is probably necessity too that leads to the extended

double-cropping (*i.e.*, taking two crops in the year) off unmanured land, a practice which usually comes in for wholesale condemnation. So far as our present knowledge goes, some cases of double-cropping certainly appear likely to impoverish the land; but, on the other hand, when one of the crops is a pulse-mixture the practice does not appear to be necessarily extravagant; though the whole subject needs more study than it has hitherto received.

Fallowing.

A cultivator does not leave ordinary land fallow for a whole year if he can help it, for the simple reason that his holding is too small for such a course to be adopted: it is therefore unnecessary to consider whether or not a regular system of fallowing would be an improvement or the reverse; but at the same time it must be noted that most fields get periods of rest from time to time. Thus in the standard rotation of rabi and kharif alternately, the rabi is followed by nearly three months' rest, and the kharif by nine or ten months (except where it includes a stand-over crop such as arhar). These lengthy periods of rest are most important as giving time for fresh supplies of mineral plant food to become available, and for the bacteria to attack the organic matter left in the soil and convert it into a form in which it can be consumed. Both processes will be materially advanced if the land is tilled early in the period so that air may penetrate it: hence the importance attached to a January ploughing for the kharif and to preparing land for the rabi as soon as possible after the kharif crops have been sown. Again, in some parts of the country a crop of sugarcane is sometimes

preceded by a full year's fallow, though I believe this course is less common than it was. In some countries an ordinary objection to leaving land fallow is that the nitrates are washed out of the bare soil, but there is little danger of this in these provinces in most of the cases mentioned above, as very little rain falls during the fallow period. In the case of sugarcane, it is becoming usual to take a quick-growing crop off the land in the rainy season instead of leaving it bare; sanai is a favourite for this purpose as it has the great advantage of growing so close that it smothers the weeds, while—being one of the plants that harbour the nitrogen bacteria—it probably leaves the soil at any rate no poorer than when it was sown.

More extended fallows are due usually to some accident of season which prevents the land being sown: thus in a year of famine many fields may bear no crop at all. It is commonly believed that such land is particularly fertile when it is again brought under cultivation, but we need hardly discuss the question, as such cases are exceptional. Apart from them the land gets as much rest as the cultivator can afford to give it.

Management of labour.

The management of labour on a holding is at first sight a complex problem. To begin with, the amount of labour that is needed varies from month to month. In July sowing and then weeding take all available hands: in August there is less to do, and the cultivator is usually able to start ploughing for the rabi, which is also his principal work in September. October is again a very busy time as the kharif harvest and the rabi sowings have to be fitted in. The

sowing over, November and December can be given to winding up the kharif harvest; then the irrigation of the rabi keeps the village busy till the end of February, and the rabi harvest begins in March. May and June are the slackest months, when the cultivator repairs his house and does any odd jobs that have been left over from the busy season. Where sugarcane is grown, the harvesting and manufacture of one crop and the sowing of the next fill up the time from January to March, and the necessary irrigation adds greatly to the work to be done in the hot weather.

The ordinary cultivator does not keep his labourers on a monthly wage: he gets as much done as possible by his family, and he may perhaps employ a ploughman regularly, but at busy times he hires his labourers by the day, paying them usually by so much grain or flour, and occasionally in cash. Further, there is a very general system of co-operation by which cultivators exchange their labour. Every man does not want his work done just at the same time as his neighbour, and so four or five cultivators may labour in the fields of each in turn, doing such work as cutting sugarcane or raising water for irrigation. This co-operative system is of great advantage: each individual is employed when he might have nothing to do on his own holding, while he gets his work done quickly and without payment at the time when it is urgent; in fact the cultivator works for the time as a labourer, but instead of getting wages in the ordinary sense he gets others to work for him in return, and does not need to keep so much capital in hand for paying wages.

The extent to which a cultivator can depend on the labour of his family is a very important element in the

economy of the farm. Among the lower castes of agriculturists every one works: thus the cultivator may be seen distributing water over his field while his son is driving the bullocks at the well, his wife empties the bucket as it comes up, and two or three small children are helping their father and patching up the water courses wherever they let the water escape. This unpaid labour is especially valuable because all alike are interested in the success of the crop, and are stimulated to work their hardest, while the hired labourer here as elsewhere wants to get through the day as easily as possible. With the higher castes it is different: the women frequently do not appear in public, and so cannot work outside the house, and labourers have to be hired to take their place. In some clans again the men hold certain kinds of labour to be "bad form:" thus some Oudh Thakurs will not plough, but must pay a ploughman to do their work for them. Such customs increase the cost of the holding very greatly, or rather this would be the case if the holding were to get all the labour it requires, but in practice the high caste cultivator usually stints his land and gets a poorer return from it, so that the holdings of these classes can often be picked out with certainty in a rapid walk through a village.

It should always be remembered that the system of cropping and the labour supply in the village fit in with each other. A village which is usually half kharif and half rabi could not be sown entirely with kharif because the necessary labour would not be available; and if it could be sown the labourers would be starving in the spring because there would be no work connected with the rabi. So again a wet cold weather is very hard on the labouring classes because

there is no irrigation to be done, and irrigation is their principal employment in January and February.

Management of cattle.

The system of cropping, however, does not depend wholly on the labour supply ; the cattle have also to be considered. A pair of bullocks cannot plough more than a certain area in a day, and the amount of land which a cultivator can sow with a particular crop is strictly limited by the work that can be done by his cattle, supplemented by any aid he can borrow from his neighbours. The amount of work that can be done by cattle depends on their strength, which can be very fairly measured by the price that is paid for them, and it is noticeable that the price declines from west to east. In the Meerut division the cultivators can pay Rs.100 to Rs.150 for a pair ; for this they get excellent animals that can pull a heavy plough and till the land thoroughly ; they can therefore do with comparatively few ploughings and can manage a large area, perhaps eight to ten acres, with a single pair. In Oudh on the other hand the price of a pair is from Rs. 30 to Rs. 60, and the plough is suited to the weaker animals ; one ploughing with it is much less effective than one with the Meerut plough, but the number of ploughings is greatly increased, often doubled, so that ultimately the tillage in the two cases is about equal. But the Oudh cultivator can manage only from four to six acres with his single pair, or little more than half the holding of the Meerut division. And what is true of tillage is equally true of irrigation ; the strong cattle work a large well bucket, and in a day may raise nearly twice the quantity of water that the weak cattle can bring up with a small bucket, so

that they can keep the larger holding fully irrigated. Thus, as a general rule, strong cattle are found where the holdings are large and weak cattle where they are small. It must not, however, be inferred that the small holdings are due to the weak cattle or *vice versâ ;* they are alike factors in the existing system. Thus the Meerut cultivator can get a fair-sized holding, and it pays him to have good cattle and gear: cut down his holding by one-half and the result might be different. The important thing to remember is that at any given time a system of agriculture exists in each locality which is composed of the size of the holdings, the class of crops, the supply of labour, the size of the cattle and various other factors. We cannot suddenly change any single factor without upsetting the system. If, for instance, we give a first class pair of bullocks to a man living on three acres, he will find it impossible to feed them off his holding: if the rate of wages rises suddenly, the class of crops grown will deteriorate; if a given crop becomes unprofitable, the labour market may be disorganised. The system, like others, will accommodate itself to gradual changes; it is conceivable (though not I think likely) that with an increase of population the Meerut holding may be reduced to the size of those that now exist in Oudh; or, to take a more improbable case, that the population of south Oudh may take to an industrial life and that the size of the holdings may increase greatly: but these changes would come about gradually, and probably would not attract notice till they were far advanced. Sudden changes of the kind are almost inconceivable.

We have insisted at some length on the importance of this point,—the inter-dependence of the parts of existing

systems,—because it explains so many things that strike us when we first look at a particular village. We may condemn practices here and suggest improvements there, but before expressing our judgments it is wise to consider how they square with the system as a whole, and whether the cultivator can reap the benefit we suggest without losing something that is at least equally valuable.

We may then conclude this chapter by repeating that to the ordinary cultivator the management of a holding is a much simpler problem than it looks when we consider it for the first time. He knows what his cattle can do, what labour he can get, what classes of crops he can grow; and he cannot afford to do much in the way of experiment. His merit and his profit alike lie in making the most of what he has got. Hard work for himself, fair work and good food for his cattle, economy in his labour bill, sedulous care for his manure heap, and the acquisition of a thorough knowledge of every part of his holding,—these constitute his more or less conscious ideal, and his success depends on the extent to which that ideal is realised.

Note to Chapter XII.

It is to be regretted that we have very few trustworthy accounts of the management of individual small holdings. The best account is to be found in the late Mr. F. N. Wright's *Memorandum on the Agriculture of the Cawnpore District*, a work which is still to be found in many libraries in the provinces.

CHAPTER XIII.

MANAGEMENT AND IMPROVEMENT OF ESTATES.

Introductory.

Hitherto we have been concerned mainly with the cultivator, that is, with the man who actually sows and reaps the

crops, whatever may be the nature of his right to occupy the land. In many villages in the provinces the cultivator and the landholder is the same person, but it is more usual for them to be distinct, and the object of the present chapter is to indicate the principles on which a landholder should deal with his cultivating tenants.

In the first place, he is not free to deal with them as he likes : the law in Agra differs in many respects from that of Oudh, but they agree in imposing various limitations on the landholder, both in the amount of rent he may charge, the measures he may take to collect it, and the circumstances in which he may get rid of a tenant. All that we have to say in this chapter assumes that the landholder does his best to act in accordance with the law, so far as he understands its provisions.

The landholder's object.

Now just as the cultivator tries to get the most out of his land, so the object of the landholder is to realise as large an income as he can. The cultivator however knows that he must manage his land so that its productive powers shall not be seriously diminished, and in the same way the landholder ought to realise, though he does not always do so, that it is his direct interest that his tenants shall be prosperous, that is to say, that they shall be in a position to make the most out of the land they occupy. In a word, the interest of the landholder is that his land shall be as productive as possible : and the share of the produce which he takes from the tenants must be so calculated that it shall not in any way affect their efficiency. The recognised

maxims of the best landholders follow directly from this central principle.

Maxims of management.

The leading maxims may be summarised as follows : The rent should be fixed for a fair term of years : it should be considerably below the highest rent which a tenant could possibly pay : it should be collected strictly in ordinary years, but leniently in years of bad produce ; a tenant who pays fairly well should be kept on the land, and when land is vacant, great care should be taken in selecting a tenant for it. If these maxims are followed, the landholder may be fairly sure that his property will not deteriorate permanently in value : when we have explained them in more detail, we will pass on to consider how its value may be actually increased.

Fixed rents.

The maxim that rent should be fixed for a term of years is in most cases embodied in the law, but it is a custom of old standing to make extra demands on the tenants in addition to the rent. Very often a landholder can in this way secure a little immediate gain, but it is at his own expense if the future is considered ; if he does not take from his tenants in all more than they can afford to pay, it is directly in his interest that the whole should be classed as rent, since the courts fix rents with reference to the standard prevailing in the locality, and it is for the landholder's advantage to keep this standard as high (within due limits) as possible. And if in all he takes more from his tenants than they can afford to pay, he contravenes the second of the

maxims we have stated. Further, if the extra demand varies from year to year with the landholder's caprice, it is likely to fall most heavily on those tenants who are doing best, and thus directly to discourage the efforts of the most skilful cultivators : that means a reduction in the produce of the estate, and that involves ultimate loss to the landholder. Again, the landholder's servants are more likely to act fraudulently in connection with these extra items than with the rent, which is known definitely and has to be accounted for.

Amount of rent.

Next as to the amount of the rent that should be fixed. When a tenant is in occupation of a holding, and competition for land is keen, it is sometimes possible for the landholder to take from him the entire produce of the holding except an amount which is barely sufficient to keep his family and his cattle alive : and this policy is deliberately adopted by a few landholders. Here too an immediate gain in income is dearly purchased in the long run. A tenant who knows that the fruit of every effort on his part will be taken by the landholder has lost the greatest incentive to making the most of his land ; at the same time his own labour, and that of his cattle, loses in efficiency for want of an adequate supply of nourishing food ; when his starved cattle die, he cannot replace them by any but the poorest and cheapest kind; he must go on using worn-out implements for want of money to purchase new ones ; in short, all causes combine to make the produce of his holding fall far short of its capacity. And when bad seasons come, he can often pay no rent at all : he has nothing laid away, and his badly tilled

land suffers far more than a properly managed holding under the same calamity. As a matter of fact, many landholders whose rents are screwed up to the highest point do not get a higher income over a series of years than those whose management is more enlightened: they may get more in a good year, but they lose very much more in bad seasons. When a cultivator knows that a substantial portion of any increased produce he may raise will belong to himself, he has every incentive to make the most of his land and of his own labour: he can afford reasonably good cattle, and can keep them in better condition; and he is in a far better position to meet adverse seasons.

We have put the case for moderate rents on the ground that they pay the landholder best in the long run, but it is needless to say that the principles of religion and morality point in the same direction; and also that the happiness of the landholder himself depends to a large extent on the relations that subsist between him and his tenantry.

Collection of rent.

When then a landholder has fixed moderate rents, he need have no hesitation in collecting them firmly in ordinary years. The tenants can pay, and are with surprisingly few exceptions ready and willing to do so, except when they have been demoralised by bad management in the past; and it is undoubtedly best to get rid of a regular defaulter without unnecessary delay. But when a bad season comes, and still more when a series of bad seasons is in progress, it is the landholder's interest as well as his duty to collect

his rents with discrimination and with regard to the circumstances of each individual. When the rains have failed and all food is at famine prices, no consideration is needed for the cultivator who has been able to sow a large area of irrigated wheat and to secure a good crop; for the high price he realises makes him able to pay his full rent without difficulty; but his neighbour who has been able to get very little water may not have more than enough produce to feed his family, and may throw up the struggle in despair unless he draws fresh hope from a prompt remission of part of his rent, or the grant of easy terms for repaying the accumulated arrears. The landholder's great object in such seasons should be to keep the tenants hopeful, and inclined to make the best of every chance that turns up: despair is the greatest danger.

Choice of new tenants.

Finally, it is obvious that when land is vacant the utmost pains should be taken in selecting a cultivator for it. One man may not perhaps offer more rent than another, but a prudent and skilful cultivator is far more likely to pay the rent regularly, and (the fact is so important that it bears repetition) the landholder's advantage lies in a moderate rent-roll which he can count on collecting, and not in a rent-roll so high that the amount collected in any year can never be estimated beforehand.

Qualifications of landholders and agents.

It is obvious that a landholder who attempts to comply with these maxims must know a great deal about the capacity of his land and the capacities of his tenants. It is

true that the larger landholders cannot know all the details of the numerous holdings on their estates ; but they can select the right type of agent, and they can know enough to make sure that the agents they have selected are working on the right lines. Indeed for a great landholder the selection and the supervision of his staff make up the principal duties that have to be performed. And it must be admitted that many landholders neglect these duties. Some lease the management of their villages for a fixed sum, an arrangement that no doubt saves the landholder trouble at the moment, but puts the tenants in the hands of an outsider who in most cases tries merely to make what he can in the short time of his lease, and who not infrequently ruins the rent-paying power of a village by his exactions. Such leases, which are known as thekas, may be justifiable for outlying portions of an estate when their situation is such that the landholder or his agent cannot visit them frequently, but in ordinary cases they have been rightly described as the negation of good management. Some landholderss, again, employ rent-collectors on nominal salaries with a tacit agreement that they will supplement these by what they can extract out of the tenants, a method that if persisted in may end by making the rent-collector a richer man than his master. No doubt it is difficult for a large landholder to look after his collectors, but it is his own interest that suffers if he does not : and nothing can go seriously wrong if he chooses his staff carefully, pays them reasonably, and sees that they are collecting only the fixed rents, are giving receipts for all they collect, and are accounting for the full demand, either as collected or as left uncollected for stated and sufficient reasons. A short personal inspection

in the circle of each collector will enable him to satisfy himself that his work is being managed properly; and if he follows the custom of the country and gives individual tenants free access, he need find no difficulty in enforcing the maxims which we have laid down.

The qualifications of a landholder to manage his own property, or of an agent to manage a large estate, may be stated as follows: He must be fairly active, and able to get about the estate; he must have an eye trained to observe details; and his mind must be alert and ready to understand anything out of the common which he comes across. Further, he should have a thorough knowledge of the capacities of the various soils in his estate, and also of the capacities of the different castes of cultivators, and so far as possible of the individual cultivators with whom he has to deal. If possible, he should add to this thorough knowledge of his own estate a general grasp of the principles of agriculture, sufficient to enable him to detect cases where existing resources are not being turned to the best advantage, and to recognise the cause of the failure, whether it be the ignorance of the cultivators, or their proverty, or any other cause. A general grasp of this kind cannot be obtained by reading a few text-books on the subject: it involves a systematic course of study, which must be obtained either at a regular agricultural school or college, or by working under an agent who himself possesses these attainments and is willing to train his assistant.

At the present day agents with these qualifications are hardly to be found, but with increased facilities for agricultural education the supply will increase if the greater landholders show a disposition to employ them. In the mean-

time it may often be the interest of a large landholder to choose one of his relatives and send him to school or college to receive the necessary training; and it is invariably a duty which a landholder owes to his family and his estate to train his successor in the art of management. A young man succeeding to a well-managed estate may ruin it in a very few years by sheer ignorance and thoughtlessness, and it is surely the landholder's duty to take what precautions he can against the ruin of his family.

Improvements.

Supposing, then, that the landholder or agent is competent to manage his estate, his particular attention will be given to detecting all cases where the gross produce is less in quantity or in value than it might otherwise be, and to remedying the defects which he may find; in other words he will always be on the look out for a chance of making improvements. Now we have seen in the preceding chapters that the ordinary cultivator is not lacking in skill, knowledge or readiness to take pains, but that he is hampered in many ways in making the best use of his land and labour. The chief defects have been pointed out: want of drainage, want of water, want of good seed, want of implements for special purposes, inferior cattle, scarcity of fuel, insufficient facilities for marketing, defective processes for preparing products, and want of means to cope with diseases are perhaps the commonest. In all these matters the landholder can assist him; and he can also give him a chance of seeing how things are done in other localities, leaving him to adopt any of the practices which he thinks will be advantageous. We cannot discuss all these subjects in

detail, but must confine ourselves to stating a few general principles that should be borne in mind.

Improvements made by cultivators.

In the first place, it is almost always better to let a cultivator make an improvement for himself than to make it for him ; he will spend less money on it, and he has a direct interest in making it as effective as possible. This principle applies to all improvements which are intended mainly for the benefit of a single holding ; thus it is usually better to lend money to cultivators who want to improve their stock of cattle than to make elaborate arrangements for importing cattle for their use. Again, it is much better for the cultivator to make a well for his holding, as indeed he usually has a legal right to do. By all means let the landholder assist him with clay and fuel, or bear the cost of any preliminary boring that may be necessary, and advance him part of the cost if he requires it, but the actual work is best done by the cultivator himself, and it is certain to be done very much cheaper.

Indirect income from improvements.

Secondly, it is very unwise to make only those improvements which will bring in a direct money income ; an improvement may pay in other ways. For instance, a well sunk on a tenant's holding may secure that the rent is paid regularly instead of having to be remitted whenever the season is unfavourable. It may even happen that the sacrifice of immediate income may be a benefit in the long run, a point that may be illustrated in connection with the question of fuel supply. We have seen that much of the dung is

regularly burnt, to the great loss of the community as a whole and of the landholder and cultivator in particular; and the only way of avoiding this loss is to increase the supply of other fuel. To do this is a difficult matter, and hardly any landholder is in a position to supply all the fuel that is needed; but a good deal can be done in a small way by encouraging the growth of quick-growing trees and shrubs wherever there is room, on the banks of tanks, on the tops of embankments, among the larger trees in groves, and so on, as well as by regulating the use of dhak and other jungles that may exist on the estate. A few landholders, instead of selling off the firewood produced in their jungles, have allowed their cultivators to cut it over in blocks year by year, at the same time agreeing with them that they shall not sell the dung so saved but shall put it on their fields; and those who have followed this policy consider that on the whole it has paid them much better than if they had sold off the firewood periodically in the usual way. It would be futile to suggest that this, or any other, policy should be adopted in estates as a general rule: the question must be worked out for himself by each landholder, and the resources of the estate utilised as far as possible.

Demonstrations.

Thirdly, the cultivator, assuming him to be a man of average capacity, knows an improvement when he sees it, but to see it takes some time. For instance, it is not enough to show him a new type of cane-mill standing idle, but he must have a chance of seeing it at work for a whole season, or perhaps more, before he can make up his mind

as to its advantages. So, too, he must see a new kind of crop growing for two or three years before he is satisfied that it will suit his holding. If then a landholder wishes to show his tenants new crops, or implements, or processes, which he thinks better than those in use on his estate, he will require a small demonstration farm, where the novelties shall be regularly on view. Now in many parts of the provinces it is already customary for the landholder to cultivate some of his own land, often for amusement almost as much as for profit, and there is no reason why, when the landholder or his agent is competent, this home-farm, or sir as it is called, should not be developed into a demonstration farm, which would add greatly to the interest of the landholder in his immediate surroundings, and at the same time would occasionally introduce new and valuable improvements on the estate.

Estate factories.

Lastly we may recur to the question of improving the processes of preparing various products for the market. It seems to us that there is room for a profitable extension of the landholder's exertions in this respect. Every large estate might work up its own products for the market, thus securing a higher quality of product, and realising a better price, which would be shared between the actual cultivator and the estate factory. The equipment of such a factory would depend on the nature of the products to be handled, and one important source of economy would lie in the fact that the power required could be supplied from a single source and applied to various processes according to the season. There might be for instance machinery for ginning and baling

cotton, for hulling rice, for baling hemp, for pressing oilseeds, for refining sugar (which would have been prepared roughly in the field by improved boiling pans lent out by the estate), for cleaning the seed to be used next season, and for any other processes that might have to be gone through. Of course such an estate factory would need an expert manager, and the landholder would have to be careful that the tenants were treated fairly and not oppressed as they were by so many indigo factories; but with reasonable precautions the thing ought to be a financial success and at the same time increase materially the resources of the cultivators.

Developments of this kind are, however, possible only on the larger estates, and with landholders who are sufficiently educated to realize the advantages which they derive from just treatment of their tenants. For smaller estates and where the landholders have not reached that stage of education, there is still ample scope for more modest improvements: there are wells to be sunk, depressions to be drained, ravines to be embanked and terraced, the fuel supply to be husbanded, and perhaps increased, village roads to be maintained and improved, and markets to be developed; some of these will pay directly for the expenditure, while all alike, if planned with judgment and carried out with economy, will increase the rent-paying power of the tenants, and thus add to the stability of the rent-roll of the estate.

Note to Chapter XIII.

A list of some possible improvements with a brief discussion of how to set about them will be found in Bulletin No. 17 of the Agricultural Series, published at the Government Press, Allahabad. For a general discussion of agricultural improvement the reader is referred to Dr. Voelcker's Report on the Improvement of Indian Agriculture, published by the Superintendent of Government Printing at Calcutta. Landholders who desire to try novelties can usually find plenty of suggestions in the various periodicals dealing with agriculture, as well as in official reports.

CHAPTER XIV.

TRADE IN AGRICULTURAL PRODUCE.

The food supply.

We have already seen that the main object of the cultivator is to feed himself and have something over. In ordinary years the provinces, taken as a whole, achieve this object, and the surplus produce is enormous though the share of a single cultivator is small. A glance at the general course of trade is valuable, as it enables us to realise something of the relative importance of different crops to the provinces as a whole. Of course the ordinary food-grains, which constitute the largest item in the whole produce, do not bulk largely in the trade returns, for they are mostly consumed in the village, or at least in the locality where they are produced: the ideal of the ordinary cultivator appears to be that when his harvest is complete he should have *at the very least* six months' store of food in hand, enough, that is, to feed his family and to pay his labourers their wages until the next harvest is ready. It is true that many cultivators are never in this position, but in their case the minimum stock has to be kept for them by the village grain-dealer who finances them, so that the total stock kept in the country for the eight or nine million families is enormous. Speaking very roughly, for no precision is attainable in these matters, a ton of grain will support a family of five for a year, so that the minimum of six months' stock represents from four to five million tons, worth, say, 16 crores at ordinary prices ; or, in other words, the provinces would require 32 crores' worth of food in an ordinary year, if no classes consumed anything but the inferior grains. We give these figures merely as an indica-

tion of the proportion which the home consumption bears to the trade with other provinces, and with the ready admission that they may be in error by twenty-five per cent in either direction; they at least help us to understand something of the greatness of the agricultural interest.

Exports.

Now when a few seasons have been good, the stock of common food in the provinces rises above the minimum, and many individuals find themselves in a position to put more of their land under money bringing crops: when this is the case there is an enormous surplus for export. Thus in the year from April 1902 to March 1903 the provinces exported on balance five crores' worth of oilseeds, and nearly the same quantity of grain. These are the two heads under which the fluctuations in trade are greatest; in the year ending in March 1897, when famine had prevailed for a large part of the year, the exports of oilseeds amounted to only 1½ crores, while five crores of grain had to be imported to meet the local deficiency; and on the whole the simplest and most certain test of the prosperity of any considerable tract of country is to examine the extent of its imports or exports of food-grains.

Next to grain and oilseeds, we may take the figures of raw cotton, sugar and opium. These do not fluctuate to anything like the same extent, varying from about 1½ to 3 crores according to the season. Cotton does not fall very greatly in a famine because, as we shall see, it thrives best on a small quantity of rain: opium is produced only on irrigated land, and is thus comparatively independent of the seasons; and something of the same kind is true of

sugar, of which the loss in very bad years is larger than that of opium, but at the same time the home consumption is reduced and the sugar placed on the market instead.

Lastly, we may notice two other classes of exports, hides and ghi, both of which have the peculiarity of increasing in years of distress. In the case of hides this is due to the mortality among the starved cattle, while in the case of ghi it is the result of enforced economy, ghi being a very common luxury and being largely consumed in prosperous years, but becoming beyond the reach of many families when grain is very dear and there is little in store.

Imports.

If we turn now to look at the figures of imports, we find that there are very few things imported in large quantities : cotton goods, metals, kerosine oil and salt are all that we need notice. Cotton goods are by far the most important, as they supply almost the whole population with everything that they wear. In the prosperous year 1902-03 no less than $5\frac{1}{4}$ crores' worth of these goods were imported, but in hard times people economise greatly in this kind of expenditure, and the imports may fall by as much as one-half. The metals in demand are brass and copper, which are used for making the household utensils that form such a large part of the specialized wealth of the people ; in good years as much as half a crore's worth of these metals is imported on balance, while in famine times the trade comes almost to a standstill. Kerosine oil is steadily coming into use among the people, and something like half a crore's worth is imported in an ordinary year : while of salt at least two crores' worth is required, which may be reduced by one-quarter in times of famine. Besides these staple

imports there are of course large numbers of articles imported in considerable quantities, but none of them are individually important enough to be mentioned in a general summary of this kind. There is however one peculiarity which must be noticed, and that is the steady absorption of gold and silver. Much of this is hoarded in the form of cash; the rest is kept in the form of jewellery, which indeed serves much the same purpose, being regularly pawned or sold in bad times. The amount of treasure absorbed in this way is practically unknown, but it mounts up to crores in a favourable year.

Summary.

On the whole, then, we may say that the people of the provinces draw most of their cash income from sugar and opium (which are fairly staple sources), from cotton (which depends more on the seasons), and from grain and oilseeds, where the influence of the season is very pronounced. They spend far more on cotton goods than on anything else, and they also import salt, which is a necessity, and kerosine oil and metals, which may be classed either as comforts or as luxuries: the rest of their spare cash goes on personal expenditure of various kinds and on adding to their savings in gold and silver. Salt is the only absolute necessary which they import in large quantities: for they could be clothed from the cotton grown in the provinces if they did not prefer cloth of a better quality than it will produce, and the place of kerosine oil could be taken by any of the vegetable oils which it is gradually superseding.

Note to Chapter XIV.

Readers who may wish to pursue this subject further will find all the materials in the Annual Reports on the Inland Trade of the Provinces, published by the Superintendent of the Government Press at Allahabad. These reports are not recommended for the general reader.

PART II.

CHAPTER XV.

THE AGRICULTURAL REGIONS OF THE PROVINCES.

Introductory.

The description contained in the foregoing chapters applies primarily to the country between the Jumna and the Himalayas, which is the productive part of the provinces. This entensive plain is not, however, altogether homogeneous but contains several well-marked types of country which it is the object of the present chapter to describe. The country south of the Jumna forms the subject of the next chapter: as regards the third division of the provinces—the hill tracts—we propose to say very little. What cultivation is to be found lies in patches on the hillsides or in the valleys, and almost every valley has its own peculiarities. The crops grown and the times of sowing and harvesting depend mainly on the altitude. The life of the hill cultivator can best be studied on the spot, and the present writer has not studied it in the detail which it requires. We may proceed therefore to consider the different regions that are to be found in the plains.

Lowlands.

The first distinction that we notice is between the lowlands along the rivers and the rest of the plains. These lowlands are known by various names such as khadir, kachhar, or

tarai: they vary in extent from the strip of land a few yards broad which we find along the smaller streams, to the ten-mile khadir of the Jumna in Bulandshahr, or the even more entensive lowland of the Gogra. These lowlands include all classes of natural soils from very heavy clays to loose sand: their distinguishing feature is their wetness, for during the rains they are for the most part either swamps or actually under water, and during the cold weather, though the surface may be dry, the soil just below it is moist, and water can be found by digging a hole a few feet deep. In these tracts, then, either no kharif is sown or it is sown largely as a speculation, a great variety of seed being often sown in the same field in the hope that something or other will give a good return. The hope is often not realised, but the speculation is cheap, as the coarsest crops are sown and the tillage is reduced to a minimum. Rabi, on the other hand, is a fairly secure crop once it is sown, as floods in the winter are almost unknown, and there is practically no danger of loss from drought: but tillage is very difficult as the land stays wet until late in the season, and time can be found for only one or two hurried ploughings. In fairly dry seasons these lowlands may be most productive, but in wet years they are very dangerous: sometimes the land is too wet to sow, if sown the crops are specially liable to disease, and worst of all the defective drainage (due to the unusual fulness of the river which should act as a drain) may allow reh to come to the surface and render the land hopelessly barren for the time being. Again, when cultivation has been prevented by any cause, the land gets rapidly covered with coarse grasses and shrubs which involve heavy expenditure in clearing the ground for the next crop. This

scrub jungle too shelters various animals which do great harm to the crops growing near them; pig and deer are the worst offenders, though occasionally serious injury is caused by herds of cattle that have run wild. Residence in the khadir is unpopular with most classes, as it is usually unhealthy and the houses may be flooded or washed completely away. Except therefore for a few castes who are more or less at home in a flood, the cultivators usually live on the upland and come down to the khadir to till: hence goind soil is almost unknown, little or no manure is used, and the land does not get the care that is given to fields within easy reach of the village.

Apart from the risk attendant on wet seasons or on the presence of wild animals, the lower parts of the lowland are at the mercy of the river itself. Sometimes it may cut a wide channel through a block of fertile fields, and sometimes it may bury good loam several inches deep in barren sand. On the other hand, it may deposit an extremely fertile silt on what was previously bad soil, and it is practically impossible to say what a field will look like after the next flood. It would therefore be waste of time to look ahead to the following season: if the land is fit for cultivation a crop is taken from it with the minimum of expenditure; if not, it is left to itself. Thus the khadir usually shows blocks of cultivation scattered through stretches of barren sand, or grass and scrub jungle; the latter is by no means valueless, as large numbers of cattle are grazed on it, and it may be the salvation of the neighbouring cultivators if a drought has left them unable for the time being to provide fodder for their cattle. There is little good timber to be found in country of this kind; babul

grows freely, and considerable areas are covered with dhak, which is good for fuel if for nothing else.

The foregoing description applies to the typical lowlands; in some places land is found at an intermediate level low enough to hold plenty of water for the rabi but high enough to escape serious floods. This upper khadir, which may be seen to perfection in Budaun, is well populated, fertile and secure; though here too the crops will be inferior when there has been a succession of wet seasons.

Divisions of the uplands.

The uplands may be divided into four main types according to the nature of the commonest soil. The natural soils are not as a rule closely intermingled; it is very rare to find a field of sand between two fields of clay or *vice versâ*, and the usual thing is to find the soil in bands, sometimes of considerable width, lying roughly parallel to the rivers. Thus we get three types of country, the bhur, the dumat, and the matiyar, to which a fourth may be added to include the garden tracts near the towns.

Bhur.

The bhur consists of a stretch of uneven sand: the field boundaries are wide and overgrown with high, coarse grasses; nearly every field has an autumn crop of bajra mixed with pulses, and rabi is comparatively rare, and when sown is usually a mixture of barley and gram. Irrigation is almost unknown, as wells cannot be made, and if they could the coarse soil would not retain the water long enough to be of use. This is a description of the worst bhur, that which is only just culturable: elsewhere we find

soil which while still called bhur has more cohesion, is fairly level, and will hold some water. Such land may be very fertile if masonry wells are made and manure is freely used, but if the cultivation is careless, the produce is almost limited in this case also to bajra and coarse pulses. A marked feature of this superior bhur is its suitability for the mango, large and prolific groves of which are to be found almost wherever it exists; indeed it may sometimes be remunerative to stop cultivating bhur and plant it with mangoes.

Matiyar.

In marked contrast to the bhur are the heavy clay tracts. The main feature of these tracts is the extent of barren stretches of the hard, compact soil which is known as usar, and is not infrequently covered with the white efflorescence called reh. The barren stretches are separated by blocks of rice fields, the fields small in size, and the field boundaries unusually high and wide; in the rains such blocks are a stretch of bright green, but once the rice is off the ground, most of the land is bare, and the rest carries mainly poor crops of gram and linseed. Wherever depressions exist in these tracts, they fill with water in the rains, and as the soil is too stiff to let the water drain away, it remains for a large part of the cold weather; such depressions are known as jhils. Timber is rare in such tracts: babul grows fairly, and occasionally nim and mohwa are to be found, but the bareness of the country is one of its most striking features.

Dumat.

Intermediate between the clay and sandy tracts is the dumat or loam, the typical landscape of the provinces. It is usually well wooded, mangoes being the commonest trees; the land bears an almost infinite variety of crops, those of the kharif being often of great height (maize, juar and sugarcane), while the low rabi crops, wheat, barley and pulses, are broken by the darker green of the arhar and in places the white expanse of the poppy fields.

Garden tracts.

A fourth type of country is to be found in the tracts adjoining those towns which stand on fairly light soil. Such soil is especially adapted to make the most of heavy manuring, as it is easily tilled and well drained; and the most skilful castes make full use of the supply of manure to be had from the town. Such land is hardly ever bare: directly one crop is off the ground another is sown, and the diversity of crops is amazing. While many towns have considerable areas of this type, perhaps the most striking are the potato-grounds near Farrukhabad and the fruit and vegetable gardens round Lucknow.

Distribution of soil tracts.

We have said above that the natural soils are to be found in bands lying roughly parallel to the rivers. It is beyond the scope of this work to give the agricultural topography of the provinces in detail, but we may illustrate this statement by a typical instance. A journey from Cawnpore to Lucknow affords an excellent opportunity of studying the distribution of soil. After crossing the Ganges bridge there

is a stretch of typical lowland for about five miles: then the line rises through a narrow strip of broken bhur, then comes level bhur and dumat, and before we reach Unao we are in regular matiyar country. This continues for twelve or fourteen miles, though it is broken near Ajgain station by an island of loam: then comes dumat running into bhur as we come to the Sai. Beyond the Sai there is bhur and light dumat about Harauni station, but by the time Amausi is reached the country is again matiyar, which continues to the environs of Lucknow. Here, if we leave the railway, we find that the light soil along the Gumti has been turned into garden land, so that this short journey gives a very fair epitome of the greater part of the plains.

Other cross-country journeys, such as those from Allahabad to Fyzabad or Shikohabad to Mainpuri, show very similar features: in some cases the band of clay soils may be missing, in others the strip of bhur is so narrow as to be barely noticeable, but as a general rule the further we go from a river the stiffer is the soil until we approach another river.

Other tracts.

By far the greatest part of the plains comes under one of these classes, khadir, bhur, matiyar, or dumat, or market-gardens, but there are a few special tracts that may be mentioned briefly. Just below the Himalayas is a belt of country known as the bhabar, mostly forest and so unhealthy that it is almost uninhabited; cultivators come down from the hills to take a rabi crop and leave as soon as the grain is gathered. Below this is the tarai, mostly heavy clay land, much of it under forest The population

is rather more settled than in the bhabar, but the climate is very unhealthy and the crops are exposed to great damage from wild animals. Along the north bank of the Jumna from Agra eastwards the soil differs from that of the duab proper, being more like what is found across the river in Bundelkhand. It is poor land, irrigation is often difficult as the wells are very deep, and the grass known as kans is apt to spread if the land is left untilled. We may also mention the ganjar, a strip of land in Sitapur and Bara Banki lying between the Gogra and Chumba rivers. It is of the khadir type, but in the rains the streams of the two rivers unite and sweep down it, causing far more damage than the ordinary, slow-moving floods of the lowlands.

It must be remembered that in the brief descriptions we have given it has been possible only to indicate the most striking features of each class of country: almost every tract has its own characteristics which can be learned only by study and observation. The upland tracts too pass into each other gradually, so that it may often be difficult to say whether a particular field is just in the bhur or just out of it, but a broader survey shows clearly enough the general line of division between the tracts.

Rainfall tracts.

We must now notice the natural divisions which result from the variations in the rainfall. We have seen already (Chapter II) that the amount of rain decreases from east to west, and also from the hills to the Jumna; the result is that the districts north of the Jumna may be divided into two main sections, the submontane and the central.

The submontane tract stretches from Saharanpur to Gorakhpur; its most striking feature is the dampness of the soil, so that irrigation for the rabi is required to a much less extent than further south, and in a few favoured localities is altogether unnecessary. The soil gets heavier on the whole from west to east, and the most valuable crops are rice and sugarcane. The extent of khadir land is another marked feature of this tract, as each river that emerges from the hills has a wide valley of its own. It might be thought that a tract so favoured in the matter of moisture would be particularly prosperous, but the water means fever, and the northern part of the tract is very unhealthy: labour is therefore scarce and inefficient, cultivators are hard to procure, and it is only the best-managed estates that are prosperous.

Adjoining the submontane districts is south Rohilkhand a small tract including Budaun, most of Shahjahanpur and parts of the neighbouring districts. This tract too is damper, but there is more need of irrigation than in the submontane districts, while the climate is much healthier. The dumat gives excellent wheat and sugarcane, and the khadir of the Ganges is unusually productive; but these two divisions are separated by a band of bhur running almost continuously from the south of Bijnor to Hardoi and presenting all the defects of such land in an aggravated form.

East of this tract comes south Oudh, including practically all Oudh south of the Gogra. In this tract the parallel bands of matiyar, dumat and bhur are most easily distinguished; from the agricultural point of view its most striking features are the skill and energy of the cultivators and

labourers, and the splendid system of well irrigation. The population is, however, very numerous and holdings are small, so that much of the land is under the coarser and commoner crops.

Still further east and keeping north of the Ganges we have most of the Benares division which with Azamgarh forms the tract usually spoken of as the eastern districts. Here the soil is largely clay, and rice is the great crop; the country is overcrowded, holdings are very small, and the people are poor.

Now if we return to Saharanpur on the extreme north and follow the right bank of the Ganges, we are in the duab proper between that river and the Jumna. The upper portion of this from Saharanpur to Aligarh is the richest part of the country. The soil is light and fertile, holdings are large, the people are well-to-do, and the admirable system of canals enables them to make the most of their land. All crops are grown, but sugarcane, wheat, and (towards the south) cotton are the great features. South and east from Aligarh to Cawnpore the duab is not so good: there is more poor land and holdings are smaller, nor is the canal system so complete. Sugarcane is very little grown, but wheat and cotton retain their importance. Finally, from Cawnpore to Allahabad the country is much poorer; sandy along the north, and on the south more like Bundelkhand. The people are not well-to-do, valuable crops are more rarely grown, and canal water has only recently been made available. These three divisions of the duab are usually spoken of as upper, middle, and lower; they are of course continuous, and it is a matter of convenience where the dividing line is drawn, but as a matter of practice Aligarh

is included in the upper duab and Cawnpore in the lower. Muttra and Agra though lying in part beyond the Jumna are usually included in the middle duab; their special features need not detain us.

CHAPTER XVI.

BUNDELKHAND.

As has been indicated in previous chapters, the districts lying south of the Jumna differ widely in regard to agriculture from those lying to the north. The difference consists partly in the habits of the people, partly in the soil, and partly in the water supply. The climate is generally of the same type as that of the duab, though the rainfall is apparently rather more liable to vary both in excess and in defect. The people, from whatever cause, are not characterised by the untiring industry that prevails elsewhere in the provinces, and almost appear to take as little trouble as possible in preparing their fields, while they show much less disposition to struggle against the adversities that come upon them from time to time.

Soils.

The soils are altogether different from those with which we have hitherto had to do. In the south of Banda, Hamirpur and Jhansi the soil is not water-borne at all, but consists of a few inches of crumbled rock lying on top of the sandstone, which is the main constituent of the land. This thin layer of soil cannot hold water for any length of

time, and a rabi crop is seldom sown on it: an inferior millet is the usual kharif crop. Even so the soil is too poor in plant food to stand continuous cropping, and after it has been cultivated for two or three years the land is left fallow until a new store of food has gradually accumulated. This is called the red-soiled country. Interspersed among these tracts of poor soil, and generally close to village sites and situated in valleys between the low hills, are little oases of stable cultivation carefully manured and regularly watered from wells sunk in the solid rock and worked by Persian wheels. The south-eastern portions of the Banda and Allahabad districts lie on the lowest and most northern plateau of the Vindhya range. This tract, locally called the patha, has much the same characteristics as that just described, but the climate is more unhealthy and the soil still thinner and poorer, only a very small proportion being cultivated. To the north of the red-soiled country we again find soils that appear to have been deposited by the action of water, but they are distinct in appearance and character from those of the duab, and must be presumed to have had a different origin, probably the hills of Central India. Four main types of these soils are recognised, which are known as mar, kabar, parwa and rakar. These may be described as follows:—

Mar is a rich black soil, soft and friable, which can be easily tilled, and may be very fertile. Its best quality is that it retains an enormous quantity of water, so that if the rains have not been very deficient, wheat can be grown successfully and does not require irrigation. If however the monsoon fails, and the soil is too hard to plough, it is

almost impossible to supply the place of natural rain by irrigation. On the other hand, when the rain at the end of the season has been excessive, there is often much difficulty in preparing a proper seed-bed in the soaked soil.

Kabar is also a dark soil, but not so dark as mar : it is much stiffer and more difficult to work : when wet it is a sticky mass that cannot be ploughed at all, and it dries exceedingly quickly, at the same time splitting into hard blocks. Thus its cultivation for the rabi is often a matter of difficulty, and it is left untilled if the rain has been either excessive or in considerable defect. This soil can also grow good crops without irrigation, provided it has been possible to prepare a seed-bed.

Parwa is a reddish or yellowish loam, resembling more nearly the soils of the duab in its behaviour towards water : it can thus be irrigated successfully when water is to be had.

These three soils are found usually in level stretches, but a distinctive feature of a Bundelkhand landscape is the wide extent of ravine land : from each river and stream a network of ravines extends inwards, and even before the ravines begin to form the land is washed into slopes. Where then one or other of the soils named above has been washed or scoured, the resulting soil is spoken of as rakar The better kinds of this are known usually as moti and the worse as patri. At its best this rakar may be little inferior to mar, but even the better kinds do not retain moisture to the same extent. At its worst it is a mass of stones and gravel, bearing only the lowest kharif, and little of that.

In addition to these typical upland soils, a stretch of fertile alluvial soil is often to be found along the margins

of the rivers and streams. These soils, which are known as kachhar and tari, are distinctly fertile, but in some places they share the risks of such soils elsewhere, being liable to be cut away or buried under sand by some vagary of the river. On the other hand it is very unlikely that they will suffer from drought.

Irrigation.

Next as regards facilities for irrigation. Though experience has shown that regular irrigation and manure can be applied to mar with good results, yet in ordinary years and for ordinary crops it does not require irrigation. The same is the case with kabar. In a dry year it is questionable how far the deficiencies of the regular rains can be made up by irrigation, but some good would doubtless result at such times from a liberal supply to these soils. Parwa needs water even in ordinary years. One river, the Betwa, feeds a canal, and canals from other rivers are contemplated, but it must be remembered that though during and just after the rains there is an enormous supply of water in these rivers, the supply stops abruptly in October, and there is a limit to the amount that can be stored in reservoirs. The rivers that come from the Himalayas have a perennial supply in the melting snow from the higher mountains, and it is this that makes them such an unfailing resource in years when the rains have been inadequate : but the Bundelkhand canals are themselves dependent on the rains of each season ; if there were no rain at all they would be almost useless, and when the fall late in the season has been seriously deficient, the supply in the

reservoirs gives out before the rabi irrigation is completed. As regards canals then Bundelkhand is much worse off than the duab.

Wells.

But the want of wells is an even more striking feature than the deficiencies of canals. Wells are fairly numerous in the south of Jhansi and Hamirpur, and in a few isolated localities elsewhere ; but in the greater part of the country, including most of Banda, Hamirpur and Jalaun, the depth to water is so great, varying from 50 to 100 feet in round numbers, that the cost and labour of raising water is almost prohibitive.

Lakes.

In the hilly country to the south the lakes constructed by the Chandels in early times by throwing embankments across the lower extremities of valleys have been utilised for irrigation, and some attempt was made to construct similar though less ambitious works as relief works during the famine of 1896-97 ; and even if these later dams are not actually used for irrigation the beds formed by them will be of great value for the growth of rabi crops. Much has been done in times gone by in many portions of Bundelkhand, but more especially in the Banda and Allahabad districts, to improve individual fields by levelling, terracing and embanking, but owing to the agricultural depression little progress has been made of late years. It is to these embankments both large and small rather than to the extension

of irrigation that the lighter soils must look for protection from deficiency of rainfall, and every effort should be made to encourage them.

Crops.

With soils such as have been described and with so little water available, it follows naturally that the crops grown are on the whole much inferior to what we have seen in the duab : the most paying crops such as poppy and sugarcane are hardly seen at all, and the outturn of crops like wheat is not more than two-thirds of what is obtained in the duab. In ordinary times the kharif area is nearly double that of the rabi : the food crops grown in the former are practically limited to juar, kodon and arhar, and the only other crops of importance are til and cotton. In the rabi gram occupies by far the largest area : wheat used to be grown more commonly than is the case now, and linseed is the only other first class staple. Thus the cropping is much less varied than in the duab, so that a calamity affecting any one of the principal crops is all the more seriously felt by the people.

Calamities.

It is comparatively rare for the country to have a really favourable season. If the rains are deficient, the kharif suffers, and there is much difficulty in preparing a rabi seed-bed : while if the rains are excessive, the kharif suffers to an almost equal degree, and the rabi seed-bed is again a source of trouble. If there is no cold weather rain, the crops on the light soils are destroyed : if there is heavy rain, the wheat and linseed are ruined by fungoid diseases, which

seem to do far more harm in Bundelkhand than in the duab. With a series of years of heavy rainfall and unfavourable ploughing seasons the heavier soils are liable to be overrun with kans (*vide* Chapter X), and once this weed is established the cultivator does not attempt to cope with it, but leaves it to wear itself out, a process of from ten to twenty years. In wet seasons again epidemic cattle disease is peculiarly fatal in the Bundelkhand districts, and the climate does not conduce to sustained efficiency among the population.

Advantages.

These numerous disadvantages are to a certain extent compensated : thus cotton thrives in a season of very short rainfall : and in the south of the tract the wild mohwa trees yield a fruit that helps to feed the people for a considerable period. The cultivator's chief advantage, however, is the lowness of rents and the absence of competition for land. The landholder has a very slight hold over him, and if an attempt is made to raise his rent to a sum which he thinks excessive, or to collect it with a strictness he considers unjust, he is ready to abandon his holding, secure of finding land within a short distance.

CHAPTER XVII.

THE PRINCIPAL CROPS—KHARIF FOOD CROPS.

In describing the crops grown the easiest order to follow is that in which they are sown. We shall therefore con-

sider first the kharif crops, which are sown from June to August, then the rabi, which are sown mainly in October and November, and lastly the crops which are not sown at either of these seasons. It is also convenient to class the crops as food and non-food, the former being those whose main produce is eaten by man or animals. Food crops again are usually divided into cereals, pulses and miscellaneous crops, while non-food crops are classed according to the nature of their principal product as oilseeds, dyes, fibres, drugs, and so on.

Nomenclature.

Before beginning to describe the crops in detail it is necessary to come to an understanding as to the names to be used. We shall speak of a crop by its English name when one is in common use, but in all other cases the commonest vernacular name will be used. Apart from these two sets of names, there is yet a third to be considered, the scientific name: it is useful to have this for reference mainly because the vernacular names differ in some cases from place to place, and also because one sometimes meets with people who know the scientific name but not that which is common in this part of the world.

Botanists have a complicated system of naming plants in accordance with their classification, but we need consider only three of their divisions, the genus, the species, and the variety. Any distinct plant is a species: thus juar is a species, gram is a species, barley is a species, and so on. Those species which resemble each other fairly closely are grouped together as a genus, to

which a separate name is given. Botanists then speak of any particular plant by the name of its genus, adding a second name to distinguish the particular species. Thus when we find wheat spoken of as *Triticum sativum*, it means that wheat as classed is belonging to the genus *triticum*, and that the word *sativum* has been agreed on to distinguish wheat from the other plants with which it has been classed. Unfortunately botanists have not always agreed on the names to be used, and one plant is still sometimes spoken of under different names by different people; the most confusing instances of this unfortunate want of agreement will be indicated in notes.

All plants in a species are not exactly the same in every respect: there is a strong general likeness with differences in detail, and plants differing in detail in this way are usually spoken of as varieties. Thus some wheat may be seen with long green spikes extending above the ears, while other plants have very short spikes, or perhaps none at all: these are usually spoken of as different varieties, bearded in the one case, bald in the other. Or again the grain of some juar is cream white in colour, while that of other juars is distinctly red: these again are distinct varieties. The question of varieties is of great practical interest to the cultivator: we shall see later on that with some crops the varieties differ greatly in the value of their produce, in their hardiness, and so on, and the cultivator's object is to grow the best-paying variety for which his climate and soil are suited. We shall find that in the case of many crops the varieties have not yet been studied in detail; in such cases it is safe to assume that the variety grown in any locality is well suited to the circumstances in which it is grown, but it is never safe to

assume that no other variety would do better, as it is quite possible that there is in some distant country a variety that would do exceedingly well if it could be tried. And further it is important to know that man can, and does, produce new varieties to order, so that there is always a prospect of improving the kind of crops grown in any place, for even if they are the best of their kind, a still better kind may be produced at any time.

As we have indicated above, we divide the kharif crops into five classes, three of which are food crops, cereals, pulses and miscellaneous, to which we add the oil-seeds and the fibres. The cereals fall into three groups, maize, which stands by itself, the rices, of which there is an enormous number of varieties, and the millets, of which several distinct species are grown.

Maize, *Zea mays*. Vernacular, **Makka** or **makai.**

(Also spoken of in the Eastern districts as *bari juar.*)

Maize grows about four or five feet high, with broad leaves, much broader than those of juar, which it otherwise most closely resembles in its earlier stages. It flowers in two places, the male flower being at the extreme top of the plant in a series of small branches, while one or more female flowers form lower down on the stem in the form of tufts of hair, often of a reddish colour. Just below these tufts the grain forms, each grain resting in a woody socket and the whole being wrapped in a sheath of leaves. Only one stem rises from each seed, and roots may often be noticed starting downwards from the stem above the level of the ground.

Maize ripens in very a short time, and therefore is of peculiar value as being one of the first crops to come in for food: hence it is sown very early, as soon as possible after the rains break, while in the canal districts the practice of sowing it before the rains appears to be spreading, though its irrigation at that time of the year is very costly. It requires fairly good land to do well, and is very commonly grown close to the village, often receiving manure: several ploughings are as a rule necessary. Each plant requires a good deal of space, and some cultivators dibble the seeds in separately, but more usually it is sown in drills behind the plough, about twelve pounds of seed going to the acre. With so much ground left vacant between the plants, weeds come up in great numbers along with the seed, and have to be carefully removed; while each plant has to have a little earth heaped round it to prevent it falling over. Cultivation is therefore a laborious business. The crop is irrigated only if sown before the rains or when a break has set in and the plants are beginning to suffer. As soon as the grain in the cobs has matured, the cobs are cut from the stalks, which are left to stand in the field, and set out to dry in the sun, and when they are quite dry the grain can be beaten out or scraped off. It is usually a large bright yellow grain which may in favourable years amount to 1,500 pounds per acre, or even more, but the average yield is estimated at rather under 1,000 pounds. It is not in very high favour as a food, but as it is ready for eating early in September when the stock of food saved from the previous rabi is running low, its success is a most important matter. Sometimes instead of waiting till the seed is quite mature the cobs are picked rather earlier and sold as they are.

They are roasted and the grain eaten: this is the more profitable course if the crop has ripened very early, as then the price for a cob is very high, but it does not pay when the regular harvest has set in. Maize is distinctly a delicate plant, and therefore its cultivation is somewhat risky. Its roots do not go deep but lie close under the surface; and as it requires enormous quantities of water, and draws its supplies from a small depth, it suffers from a break in the rains more quickly than any other crop. On the other hand, waterlogging is equally disastrous: the crop is never sown in lowlying fields, and if any water collects in places it must be drained off at once, or the plant will begin to suffer. The shallowness of its roots is also accountable for the ease with which plants are blown over and broken, and it is this that makes the expensive earthing-up necessary. As soon as the cobs have formed they have to be protected from porcupines, squirrels, parrots and jackals, and particularly from thieves, so that the crop has to be watched regularly. On the other hand, maize has the great advantage that it is almost beyond danger from a dry September. We have seen in an earlier chapter that a failure of the rains in September may turn a promising season into one of distress, or even famine: the earliness with which maize ripens renders it safe from this danger provided its sowing has not been delayed.

Maize is found in most parts of the provinces, but it is commonest in the Meerut and Fyzabad divisions: it is almost unknown in parts of Bundelkhand. Apart from the common type with bright yellow seeds, there is a distinct variety grown at Jaunpur with pale waxy seeds: the whole plant is larger than in the common type, the cobs far larger

and the produce greater : on the other hand, it does not mature so quickly. One great advantage of the common maize is that it leaves the ground vacant in time for sowing a rabi crop, while with the Jaunpur variety there is not time for any but rough tillage.

The stalks are nutritious fodder if cut while green, but by the time the crop has ripened they have become so hard and woody that they are almost useless for anything except thatching or fuel.

Rice. Oryza sativa. Vernacular, **Dhan.**

The number of varieties of rice is very large, and they have not been studied in much detail. They fall, however, into two main groups, those that are sown broadcast in the field and ripen in less than three months (called *bhadoi* or *kuari*), and those which are sown in nurseries, then transplanted into the fields, and mature in from four to five months. Transplanted rice is usually spoken of as *jarhan*. All alike are bright green plants of height varying from two to four feet with the grain arranged loosely on long feathery ears : and all have the remarkable character that they do not require much air in the soil, while their consumption of water is so great that they grow best when the ground is thoroughly saturated, or even under water. For this reason the crop is grown only on the clays and the heaviest loams which are practically undrained and hold the rainwater at their surface.

Broadcasted rice is sown as soon as possible after the rains break : the land is ploughed two or three times, and the ploughs may be seen working almost under water when the first rain has been heavy. Sometimes after an early fall

of rain the seed is sown while the ground is still very dry: if so, it does not germinate but remains in the ground till more rain falls; the object of this practice is to save time, for the crop comes up after the first regular rain when other fields are only being ploughed. The seed is sown fairly thickly, about 80 lbs. going to the acre, and the young plants have to be weeded carefully. This done they need no more attention unless there is a long break in the rains, when they are irrigated from streams, canals or ponds, whichever may be available. Wells are practically useless in this case, as the small flow of water that can be raised from them is not enough for the crop. In August or September the rice ripens, and the plants are cut by the sickle, and then usually beaten to get the grain out of the ear. The grain so obtained is enclosed in a hard husk, which is separated by pounding in a mortar: the product is the well-known white rice which is called *chawal*. The husks are useful food for cattle if there is enough of them. The outturn of unhusked rice appears to vary from 800 to 1,000 lbs. per acre, of which about one-quarter is lost in husking.

Transplanted rice is first sown very thickly in small plots of very highly manured land: when the seedlings are about a foot high, usually about the beginning of August, they are taken up and planted out in the field in regular lines. The field must be under water, or at least thoroughly soaked, when this operation is carried out. If conditions are favourable, each plant, of which from two to six are usually planted together, sends up a great number of stems, which develop far more freely than when the plants are sown broadcast. The heavy crop consumes enormous quantities of water, and in dry

weather irrigation is necessary: weeding has also to be done if the land is not free from weeds. The crop ripens usually in November, and is harvested in the same way as broadcasted rice; the outturn is probably from 1,200 to 1,400lbs. to the acre, and the quality of the rice is better, commanding much higher prices. Thus it pays to grow transplanted rice though the cost of cultivation is more than twice as high as the broadcasted varieties, provided the weather is suitable, but it is much the more speculative crop of the two.

Early rice is fairly secure provided there is good rain in July and August, and it suffers very little from excess of rain unless the plants are practically washed out of the ground. It does not suffer greatly from pests except occasionally from caterpillars when the weather favours their multiplication. Later rice too is hardly ever damaged by excess of rain, but any deficiency is a serious matter. To begin with, if there is a break early in August, transplantation is much delayed, and thus part of the growing season is lost: then any deficiency of rain in September causes serious loss, unless where a great deal of water is available, as where the land can be flushed from the canal. With a really dry September, like that of 1896, the crop is completely lost in most places, for the water that has accumulated in the tanks and swamps is nearly all used up by the end of the month and the crop withers in October. The rice sapper too, a small bug which usually appears at the end of August, does far more harm to the transplanted rice than to the broadcasted rice which is then ripening.

Rice is grown only where there is a good chance of getting enough water. Thus it is the principal crop in Rohilkhand, Fyzabad, Gorakhpur and Benares, and the best

qualities are largely grown in places where canal water is available. On the other hand, it is almost unknown in the dry districts of Muttra and Agra, as well as in large parts of Bundelkhand.

Rice straw, which is known as *pial*, is exceedingly poor fodder, and cattle eat it only when they can get nothing else, which is unfortunately often their position in rice districts.

Millets.

There are two types of millets, (1) *juar* and *bajra*, which are tall plants growing from six feet to eight feet or more, and (2) the small millets, *mandua*, *kodon*, and so on, which grow only from two or three feet.

Juar. Andropogon sorghum.*

This is a tall, erect plant, with broad dark-green leaves and the grain carried on a single large head growing from the top of the stem ; as the grain matures, this head usually bends over with the weight. Juar is the commonest kharif crop in almost all places where rice is not the staple : it is grown usually on loam or even clay, rarely on the lightest soils ; it does not get very much in the way of manure and from two to four ploughings are usually considered sufficient ; it is not irrigated unless there has been a break in the rains long enough to dry up the land. It is sown in July as soon as the earliest sowings (cotton, maize, &c.) have been finished. The crop has to be weeded, and it is a common practice to plough the field when the plants are

* Juar has also been called *Holcus sorghum*, and *Sorghum vulgare*.

about a foot high, thus loosening the earth where it may have been caked by the rain. As a rule juar is not sown alone, but is mixed with arhar, and some of the small pulses, but it grows much faster than these crops and soon becomes the predominant feature in the field. As soon as the grain begins to form, the crop has to be watched as birds may do a great deal of mischief by picking out the grain from the head. It is usually ripe in November, when the heads are cut with sickles and the grain trodden out by bullocks ; very often the best heads are picked out and set aside for the next year's seed (*vide* Chapter V). The outturn of grain when the juar is sown by itself is probably nearly six hundred pounds to the acre, while when arhar and other crops are sown in the same field, it is perhaps from four to five hundred pounds. The grain is the staple food of the poorer classes during a large part of the year.

The great danger to juar is an early cessation of the rains : showers in September are essential if grain is to be matured. It suffers also from a fungus which feeds on the grain and may be recognised by its leaving a mass of black powder where the grain should be : the borers also do harm by settling in the stem and consuming the supplies of food for the seed ; and fungus on the leaves is very common, but does not apparently cause much loss in ordinary cases. Apart from drought the greatest injury is likely to result from heavy wind and rain early in October when the plant is in flower : the flowers are open and exposed from their position, and the rain prevents them being fertilised, so that little or no grain sets. In its earlier stages juar can stand a great deal of rain, provided the land is not actually under water.

The stems of the plant are an excellent fodder, and form the mainstay of the cattle from December to April, being chopped into short lengths as required. In the Meerut division, and to a less extent elsewhere, juar is sown only for fodder. In this case it is sown as early as possible, and to an increasing extent with irrigation before the rains break, manure is often applied, no other crop is mixed with it, and the seed is sown much closer together. The fodder is cut as required for use, and a second smaller crop is often obtained in favourable weather from the patches that are cut earliest. This supply of fodder coming at a time when that from the rabi is almost exhausted is of the utmost benefit.

The number of varieties is large, and they have not yet been studied in detail. The differences consist partly in the size of the plants, partly in the colour of the grain, and partly in its arrangement on the head.

Bajra. Pennisetum typhoideum.*

In its earlier stages bajra has a general resemblance to juar, but the stem is thinner and the leaf narrower. The head is distinctly different, being a long narrow spike, rather like the head of a bulrush, with the grains packed closely together on it. It is usually sown on poor sandy soils, with no manure, and is hardly ever irrigated. The tillage is rough, and as a rule the seed is sown broadcast mixed with arhar and one of the small pulses. Bajra can be sown a good deal later than juar, and so occasionally replaces it when sowings have been delayed. The crop is weeded, and sometimes ploughed over in the same way as juar, and then

* Bajra is also called *Pennicilaria spicata*, and *Panicum spicatum*.

needs no more attention till the ears begin to set grain, when it should be watched to keep the birds off. It ripens rather earlier than juar, about the end of October, and is harvested in the same way. The outturn is less, about 500 lbs. of grain when the crop is sown alone and 400 to 450 when sown with arhar. The grain is one of the chief foods of the poorer classes : when people have the choice they eat bajra in the cold weather and juar in the hot, as they find the former a more heating food.

Bajra is rather deeper-rooted than juar, which is probably why it is always sown on the sandy soils ; it is scarcely ever exposed to danger from waterlogging as the sandy soils drain quickly, but it may be a total loss if September is dry. The flowers are very much exposed, and if rain falls in the beginning of October fertilisation is very much interfered with and the outturn greatly reduced : when the rain has been heavy and accompanied by strong wind, head after head may be found in a field with scarcely a single grain on it. It is also occasionally attacked by fungi in the ears or on the leaves.

The stalks are used as fodder in the same way as juar, but they are much less nutritious, and the crop is rarely grown for fodder alone. The crop is grown most commonly in the Agra and Rohilkhand divisions, and is very rare in the east of the provinces.

Small Millets.

There are four common small millets, of which the commonest names are mandua, kodon, sawan, and kakun ; the names, however, vary greatly from place to place. Sawan, a kharif crop, must not be confused with the hot weather

millet which goes by the same name in parts of the provinces, but which is usually called chehna.

Mandua. Pleusine coracana.

Mandua is often spoken of as makra. It is a great staple in the hills, but in the plains though grown in many places it is common only in Oudh and the eastern districts. The plant grows from two to four feet high and looks like an erect grass ; the seed is carried on a head consisting of rather bushy spikes standing erect on the stem. It prefers light soils, and is sown as early as possible, usually with slight tillage ; sometimes, however, it is sown in nurseries and transplanted in the same way as rice. It is weeded but gets no other attention, and matures very rapidly, ripening usually in August and giving a heavy outturn of grain, often 1000 pounds per acre or upwards. But though the yield is heavy it is not a popular food, and no one eats it who can get anything more palatable.

Mandua does best with a light rainfall and suffers severely from any excess : this is probably one reason why it is sown largely in some of the rice districts, as a sort of insurance in case the season may be too dry for rice.

Kodon. Paspalum scrobiculatum.

Kodon resembles mandua in its growth, but the head is much more compact and the seed darker in colour. It is grown only where the land is poor, and is eaten by those who can get nothing better. The crop is commonest in Bundelkhand on the higher fields, and in Mirzapur on the hillsides : in Oudh it is frequently grown mixed with rice in the poorer fields as it gives a good yield in moderately dry seasons when the rice suffers. The tillage given is rough;

but weeding has to be carefully done: the crop ripens in October and gives yields of up to 1,000 lbs. per acre, but a large proportion of this is husk, which is very thick and can be separated only with difficulty; hence the heads are left lying for some time after cutting to loosen the grain. The crop is largely protected from birds, owing to the way the grain is set in the head: but it suffers a good deal from insects and also from either excess or serious defect of rain. Speaking generally, wherever kodon is sown on a large area it means that the land is poor, and probably the people are poor also.

Sawan. Panicum frumentaceum.

Sawan grows to about the same size as mandua, but has broader leaves and an open feathery head. Its grain is perhaps more popular for religious use than for food, but it ripens in such a short time, sometimes within six weeks of sowing, that it is widely grown where the people are poor and have very little reserve of food: it is commonest in some parts of Rohilkhand, and in Bundelkhand and the eastern districts. As the crop is valuable mainly on account of its earliness, it is sown as soon as the rains break, sometimes in fact earlier, in the same way as broadcast rice: it does best on light soils, and the only attention it requires is careful weeding. It is usually ripe before the end of August and yields up to about 800 lbs. per acre on good land, but probably less than half of this in the poorer soils of Bundelkhand.

Like most of the other small millets sawan does best when the rainfall is somewhat light and suffers severely from any excess.

Kakun. Setaria italica.

Kakun when young looks rather like a miniature juar plant, but its head is shaped like a knobby spike, which droops over as the weight of the grain increases. It is not a very common crop, but can be seen in most districts. It is sown early, often on highly manured land, and ripens in September, giving about 400 lbs. of grain to the acre. Differing from the other small millets it is a popular food, though like bajra it is considered to be heating. Its greatest enemies are the birds as its grain is exposed.

One other small millet may be briefly mentioned ; it is grown only in the south of Bundelkhand, where it as called kutki, and in Mirzapur, where it is known as mijhri. It is very little better than a wild grass, and is grown on the very poorest soils, yielding about 150 lbs. of grain to the acre.

Autumn pulses.

The autumn pulses are arhar, urd (or mash), mung, moth, lobia and guar. As a general rule these crops are hardly ever grown alone, but are mixed with other kharif crops. We have already noticed their great importance in maintaining the stock of combined nitrogen in the soil, while the produce is valuable food for both men and animals.

Arhar. Cajanus indicus.

Arhar is quite different in appearance from the common field crops, growing to a thick bush with a woody stem ; the leaves are narrow and of a darker green than most crops, and the roots go a great way into the soil. The crop is usually sown with juar, bajra and cotton : it germinates along with these, but it grows much more slowly than the large millets, and when they are cut the arhar plants are short and

slender. They are then left on the ground with no further tillage, as the plants are high above weeds and their deep roots enable them to draw water from a long way down, and thus render irrigation unnecessary. The plant flowers in the cold weather, the flowers being bright yellow; and then pods form which contain the seeds arranged in a row. When ripe in March or April the plants have to be cut down with a hoe, being too strong for the ordinary sickle; the leaves and pods are stripped off and the grain is either trodden or beaten out, and winnowed in the usual way. In the rare cases where it has been sown alone, the outturn may be from 500 to 600 lbs. per acre, while if grown with the millets it is usually less than 400 lbs., and varies inversely with the outturn of the millet; when the latter has been a heavy crop, the arhar is usually poor, and *vice versâ.* A striking instance of this was seen in 1896-7 when the millets had been very poor in some parts of Oudh; the arhar in that year flowered early, and after the pods had been gathered it flowered a second time and gave a further crop.

When arhar is sown with cotton, it is usually placed in lines about fifteen feet apart; it grows thick and high as cotton is a low-growing plant, and it is of particular value as a shelter; the outturn from a cotton field is not however as great as from a millet field as the arhar plants are far fewer in number. It may be added that arhar should never be sown with the finer kinds of cotton, as these are spreading plants and their growth is much affected by any crowding.

Arhar seems to survive any deficiency of rain short of an absolute drought, and is almost independent of cold weather rain, while nothing short of regular floods seem to injure it seriously, but it has dangers of its own.

The greatest is frost, to which the plant is more liable than any other of our field crops: a single ground frost may destroy the entire crop. The damage is always greatest on the light soils, and is unavoidable though occasionally the crop may be saved by prompt irrigation. The caterpillar known usually as *chheda* does a good deal of harm in some seasons, boring into the pods and eating the young seeds.

Arhar is comparatively little sown in the western districts where the danger from frost is greatest, though even there it is often to be seen in the cotton fields, but it is almost universal in the rest of the provinces. There are some varieties, but nothing definite is known of their relative value.

The dry leaves and pods make most nourishing food for cattle, and the stalks are put to a great variety of uses, the chief of which is lining temporary wells. For this purpose the stalks are bound into a long rope, which is coiled round the inside of the well.

Urd or mash. Phaseolus radiatus.

This and the remaining kharif pulses are quite different in appearance from arhar. Urd is a low creeping plant which forms a dense mat over the ground, and as in most pulses the seed is arranged in pods. Urd is very commonly sown alone in north Oudh and Rohilkhand, and when so sown it need not be put into the ground till the other kharif has been sown, and is often not sown till late in August: but it is most commonly mixed with the large millets and arhar, and then it is sown along with them. Once sown it gets no further attention till it is ready for harvesting: there is an early variety which is ripe in August

or September, but most of what is sown ripens in November, when the plants are pulled up or cut, carried to the threshing-floor and the grain trodden out. When sown alone it yields about 400 lbs. of grain, and the bhusa or trodden straw is very rich fodder. The outturn of the mixed crop depends largely on what has happened to the millets : if they have failed, the urd may be excellent, while if they are good it is usually poor. Urd is of value not only as supplying combined nitrogen and as an insurance against failure of the other crops, but also as shading the ground and thus economising moisture in dry weather. This is probably one reason why it does so very well in a dry September, but on the other hand excessive rain in that month is fatal to it : in such seasons the plants suffer greatly from some kind of fungus on the leaves, while the pods are ravaged by caterpillars, and if the rain comes while the plants are flowering fertilisation is prevented and no grain forms.

Mung. Phaseolus mungo.

Mung is exceedingly like urd : in the field it has leaves of a darker green, while the seeds are larger and longer. There are three varieties, of which the commonest is that with green seeds, the others being black and yellow. There does not seem to be any early ripening variety, but with this exception all that has been said of urd applies equally to mung.

Moth. Phaseolus aconitifolius.

Moth is another plant of the same type, but it can be easily recognised by the outlines of its leaves, which are

broken into numerous points while those of mung and urd have an even outline. It is either grown by itself on the very worst land or mixed with bajra on inferior sandy soils. It is cultivated roughly, and gives a relatively heavy outturn, sometimes over 600 lbs. to the acre, if things are favourable, but like bajra and the other pulses it is very liable to injury from rain at flowering time. The grain is eaten, but it is a very unpopular food, and most of it is probably given to cattle, which thrive on it.

Lubia. Vigna catiang.

The leaves of lubia are very like those of urd or mung, but are smoother, while the plant climbs when it can rather than creep, and the flowers are a reddish purple. It is very rarely sown alone, but is mixed in millet fields like the other pulses and may often be seen climbing up the stems of the millets : it does best in fairly dry seasons, and yields about the same quantity of grain as urd ; the grain however is by no means so much relished.

There is a variety of this crop with very long pods which is grown as a vegetable ; the pods have a superficial resemblance to French beans. With this may be mentioned the plant known as sem, a long climbing pulse with flowers of varying colours, which may often be seen along the borders of millet fields and especially climbing on the castor plants. It is used as a vegetable.

Guar. Cyamopsis psoralioides.

This pulse too is occasionally grown as a vegetable, but its principal use is for cattle food. Differing from urd, etc., it grows upright. It is sown when the rains break, and

ripens in October, giving about 800 lbs. of grain to the acre. It is also sometimes cut for fodder while green, and may be grown along with juar for this purpose. Its growth is almost confined to the western districts.

Miscellaneous food crops.

The miscellaneous food crops grown in the kharif season are not of great importance; the following may be mentioned :—

Sweet potato. Ipomæa batatas. Vernacular, Shakkarqand.

This is a low creeping plant which covers the ground thickly with a mass of smooth leaves. It is not grown for its seed, but is one of the plants which store up food in their roots for a later period of growth. Cut pieces of the root are planted in the ground early in the rains: each of them starts a new plant, and by December these have formed large thick roots, which are dug up for food. These are eaten as a vegetable, often curried, and are also used in preparing various sweetmeats. The leaves are good food for cattle.

Ramdana (*Amaranthus candatus*), which is grown largely in the hills, is also to be seen in many parts of the plains growing along with low pulses and occasionally other crops. The whole upper part of the plant is of a deep red colour, rising to a large plume, which contains the seeds. This crop is sown in the rains and ripens in October; it is of no particular importance as a food supply in the plains, but its magnificent colour renders even a few plants a conspicuous object in a field.

CHAPTER XVIII.

THE PRINCIPAL CROPS.—KHARIF NON-FOOD CROPS.

Among the kharif crops which are not used for food only five are of sufficient importance to require separate notice; two of these are oilseeds and the remainder fibres.

Til. Sesamum indicum.

The til plant is one of the chief sources of the oil used so extensively by the people. It is an erect plant from three to four feet high, and the oil is obtained from the seeds, which are found in great numbers in the capsules at the upper end of the stem. Til is almost always sown along with juar, bajra and cotton, being sometimes broadcasted along with the other crops, and sometimes sown separately in lines through them, and especially round the borders of the fields. It ripens in October or November, when the plants are cut with a sickle, and allowed to dry in bundles. They are then beaten on the ground, when the seed falls out of the capsules. The stalks are used for fuel.

Til is grown by itself in some of the submontane districts, and very largely in Bundelkhand. In this case it is usually sown on very poor land with hurried and imperfect tillage, and yields about 300 lbs. of seed to the acre: it can be sown as late as August.

The great danger to til is rain at flowering time, and hence heavy storms in the beginning of October may result in the almost entire failure of the crop.

The oil is got out of the seeds by pressing in a simple wooden mill worked by a bullock: it is almost universally used with food and for cooking, and to a less extent in the toilet and for burning. The residue of the seeds after the oil has been pressed out is known as oilcake, and is a very valuable food for cattle—indeed it is occasionally eaten by the poor.

There is considerable trade in this oilseed, which is known in European markets as sesame or gingelly, the latter term being the name current for the crop in South India.

There are two varieties, one with black, the other with white seeds: the oil of the latter is preferred for use with food.

Castor. Ricinus communis. Vernacular, Arend or rendi.

Castor is a tall and quick-growing plant, growing almost to the size of a small tree in one season: its leaves are large and have a marked tinge of light blue on the stalks and under-surface: the seed is borne in a group of spiked clusters at the crown of the plant. It is very rarely sown alone, though small plots are occasionally to be seen close to villages or sometimes on river banks; but it is most commonly grown as a sort of hedge to fields of sugarcane, cotton and other kharif crops, sometimes also on banks along the roads and paths. It does best where it has a great deal of space and is in no danger of waterlogging. The seeds are either sown behind the plough about 18 inches apart or planted singly by hand about the beginning of the rains or even a little before. The crop ripens about March, when the capsules are gathered, and either allowed to dry in the sun or buried in

the ground till they rot. Then the seeds are taken out, heated for a short while, crushed in a mortar, and then boiled in water: the oil is skimmed off as it comes to the surface of the water. It is used for lighting and to a less extent for oiling cart-wheels and the other simple machinery in use among the people.

Cotton. Gossypium neglectum. Vernacular, Bari, ban, kapas.

Cotton is one of the great crops of the provinces, forming as it does the raw material for the clothing of almost the whole population. It is rather a bushy plant growing about four feet high with broad leaves greatly indented. The flower is mainly yellow, and the seed when it forms is enclosed in a mass of soft white fibre, which is the chief product of the crop. Cotton should be sown as early as possible after the beginning of the rains: in fact there is no doubt that the growing season in these provinces is too short for the plant to reach perfection, and the practice is spreading of sowing it in June or even in May with the aid of canal water.

North of the Jumna the crop is usually grown on fairly good land, and often with manure. The soil should be loam, light rather than heavy, and so placed as to be out of the reach of stagnant water: it is usually well tilled, and weeded whenever necessary; as has been noticed above, arhar and til are frequently grown in the same field. Cotton requires a season of light rain, and in fact there is a saying that it does best in a "half-famine." The seed forms in closed pods, which are spoken of as bolls; these begin to open in October or November, when the seed is ripe, and the seed with the fibre adhering to it is gathered by hand as

the bolls open. The field is picked over every third or fourth day if necessary, and the cotton gathered as it appears picking may go on till January in favourable years.

The next step is to separate the seed from the fibre: this is usually done by passing the fibre between two wooden rollers in a little machine called charkhi, but an increasing amount is separated by the steam ginning mills, which are springing up over the cotton districts. The seed is a valuable food for cattle; it contains a good deal of oil, but no use is made of this by the people, and the question whether it would pay to extract it has been under discussion for the last year or two: it is entirely a commercial question, and we need not linger over it.

As has been said above, cotton does best in seasons of light rainfall. Any accumulation of water in the field is ruinous to the crop, and much damage is sure to result from rain late in the season. A great variety of insects also injure the product by feeding on the seed; when they do this, the oil runs out into the fibre and weakens and discolours it so as to render it almost unsaleable. Caterpillars also may do a great deal of harm by stripping the plant of leaves; and finally frost often kills off the plants, or at any rate puts a stop to the production of seed and fibre a fortnight before the time when the picking would otherwise ordinarily end.

Cotton is grown mainly in the west of the provinces, where the rainfall is less than in the east, and where a wet September is rare. It is also very largely grown in Bundelkhand, but it is rare in Oudh and the eastern districts, where the heavier rainfall and the prevailing clay soils are not adapted to the plant. In a few places in the east a distinct

variety of cotton, known as narma, is grown. This gives its produce only in the hot weather when it has occupied the ground for ten or eleven months.

The yield of fibre probably varies from 150 to 200 lbs. to the acre, but the crop is distinctly speculative, and much higher and much lower yields are probably common, while the length of the picking season makes it very difficult to ascertain the outturn with any approach to accuracy. The great defects of the cotton grown in these provinces are the shortness and coarseness of the fibre, which make it unsuitable for spinning any but the coarsest yarns. There is an increasing demand all over the world for finer cotton, and some of the best kinds have from time to time been grown successfully at Cawnpore and elsewhere, but it is still an unsettled question whether they can be grown at a profit with the resources at the cultivator's disposal.

San-hemp. Crotolaria juncea. Vernacular, **San, sanai.**

This plant must not be confused with the true hemp which is known in vernacular as bhang, and is cultivated in the hills, and rarely in the plains, for the intoxicating drugs which it produces. San-hemp grows in long slender stems from four to eight feet high, with scanty leaves and small, bright yellow flowers. It does well on poor soils provided they are not waterlogged. Most usually it is sown as a border to cotton and juar fields, but in an increasing degree it is sown by itself: in this case the seeds are sown very close together so that the plants are forced to grow to a considerable height: it smothers all weeds by the rapidity of its growth, so much so that when a field has got full of weeds it is usual to take a crop of san off it in order to clean

it. Some plants are left standing until November in order that the seed may mature, but to get the best fibre the crop is cut down while in flower, the leafy tops are given to cattle while the long stems are made into bundles and soaked in a waterhole to loosen the fibres which grow round the wood of the stems. When sufficiently loose the stems are beaten on the surface of the water and the fibres come off easily. When it has been grown in small patches or as a field border, the fibre is kept by the cultivator for his own use, and is made into well ropes, string, and so on. But a considerable trade with Europe has arisen in this fibre during recent years, particularly in Rohilkhand, and large quantities are exported. The growth of this crop fits in well with sugarcane ; it is one of those which supply combined nitrogen to the soil, so that when it is grown the land is left free from weeds and in good condition for the cane.

The outturn is about 600 to 700 lbs. of cleaned fibre to the acre. The crop is grown most widely in Rohilkhand and Allahabad : it seems to be wonderfully free from risk of injury provided it can be sown in time and the weather is not altogether abnormal.

Roselle hemp. Hibiscus cannabinus. Vernacular Patsan.

This crop is hardly ever grown alone but is sown as a border with various kharif crops. It is quite different in appearance from san-hemp, shorter and bushier with large, open, red and yellow flowers. There seem to be no points of special interest connected with its cultivation : when ripe the plants are cut or pulled, soaked in water, and the bark pulled off by hand. The fibre so obtained is softer, whiter

and silkier than that of san-hemp, but is much weaker, and sells for much less. It is grown almost entirely for domestic use, and is used for making coarse cloth or sacking, and for the finer qualities of string; the best qualities come from Meerut and from the north of Oudh.

CHAPTER XIX.

THE PRINCIPAL CROPS.—RABI FOOD CROPS.

Wheat. Triticum sativum. Vernacular, Gehun.

Wheat is the great rabi crop of the provinces. It is too well known to need description, but we may just mention that almost all the varieties common in the provinces have a fair-sized "beard" as the projections on the tips of the ears are called. It is sown in the latter part of October in any loam, and in lighter clays and heavier sands. Usually the land has borne no crop in the kharif, but the practice of sowing it after maize appears to be spreading. The crop needs very thorough tillage if it is to be remunerative, and ploughing for it usually begins in August, as soon as the kharif has been got into the ground. Ploughing continues in the intervals of the rains, and usually eight or more ploughings are given: when the rain is over manure (which is applied frequently) is spread on the field and ploughed in; then tillage goes on, the plough and the clod-crusher being used until the seed-bed is just right in point of moisture and temperature. When this point has been attained the seed is usually sown behind the plough, being broadcasted only when the land is on the wet side. If the land is wet, the clod-crusher is not used after sowing, but in ordinary seasons its use is general, so

that moisture for the seed-bed is brought up from below. The next step is to throw up small ridges in the field dividing it into squares to facilitate irrigation. The first watering is usually given early in December, after which the field is weeded if necessary ; a second watering follows in January, and usually a third in February, unless rain has fallen in the meantime. The crop ripens in March or April, and is cut by sickles and carried to the threshing-floor, where the grain is trodden out by cattle in the usual way.

The first great danger to the wheat-grower is that by the time the temperature has fallen sufficiently for sowing the ground may be too dry. The seed is expensive and a large quantity (100 to 140 ℔s. to the acre) is sown, so that the loss of the seed cannot be risked. It is therefore often necessary to water the field before sowing ; this watering (which is usually called paleo) is easily done in the canal districts, but costs much labour and takes much time where the water has to be raised from wells : after a dry September, however, it is done as a matter of course. The next danger, a heavy fall of rain in October, depends for its effect very much on the exact time of its occurrence. If the land is nearly ready for sowing, the loss may be serious, for the seed-bed is compacted by the force of the rain, and there is not time to prepare it properly again ; while if rain falls just after the seed has been sown, as happened in some places in 1894, the seed may rot and resowing be necessary. Once the plants have made a start the great danger is wet and cloudy weather during January and February : the great majority of the wheat is sown on land that can be irrigated ; and though light falls of rain, followed immediately by bright sun, are of great value as saving the labour of

one or more waterings, any prolongation of the damp weather at once gives rise to the greatest anxiety, as it is almost sure to be followed by the spread of rust. We have already indicated the ruinous effect which this fungus may have, and we need only add that on the experience of recent years the injury is most to be feared in Bundelkhand and in Oudh. It is hardly too much to say that wheat-growers who have plenty of water at their disposal actually prefer a perfectly dry cold weather, and there is no doubt that the highest outturns have been obtained in years of this character.

When high west winds set in early in February the outturn of wheat is reduced, as the grain in the ear tends to dry prematurely and shrivel.

The fungi which are known as smut and bunt and give so much trouble in many countries are very rare in these provinces, but on the other hand there is occasional injury from the disease known as sehwan, when the grain is found to be infested with minute worms.

The outturn of irrigated wheat averages about 1,200 lbs. to the acre, and only about five per cent of the weight is lost in grinding it into ata or meal. The best wheat comes from the western districts, especially Meerut and Muzaffarnagar, and the quality on the whole decreases as one goes east. The cultivators in the eastern districts are in many cases too poor to undertake the cultivation of this crop, and the area under it is proportionately less there than elsewhere. Ata is the food of the upper classes, and the lower classes eat it when they can get it, which unfortunately is rarely the case. In good seasons the province produces much more wheat than it consumes, and the balance is exported to Europe.

Rape (sarson) is usually grown in the field with wheat and harvested separately ; there are two common mixtures, wheat-barley and wheat-gram. Wheat-barley is called gujai, and is frequently sown in the eastern half of the provinces : the two grains are harvested and threshed together and ground together as flour. Wheat-gram is more common in the western districts, and is the usual crop in Bundelkhand ; in the latter case water for irrigation is not usually available, and though the soils are very retentive of moisture it is risky to sow wheat entirely by itself. It is therefore usually mixed with gram, which often gives a good crop when the wheat is worthless, and also benefits the wheat by shading the surface of the soil, and thus minimising loss of water by evaporation. It should be added that the amount of wheat grown in Bundelkhand, whether alone or mixed with gram, has fallen off largely in the last ten years, owing in great part to the loss from rust in 1893 and 1894.

The varieties of wheat are almost innumerable : the main distinction between them is that of the hard and soft grains; the former when ripe are almost transparent, while the latter are opaque and much easier to cut. The hard wheat contains a higher proportion of nitrogenous matter, and is therefore the more nourishing of the two, but in many parts of the provinces the softer wheats are preferred, for one thing because they are much easier to grind in the small stone handmills which are still in general use. Another distinction between varieties is the colour of the grain, which varies from almost white to dark brown or red. The soft white wheat is usually called dudia : red wheat is lallia, while beardless wheats are mundia. In Bundelkhand, where

most of the wheat is red, the term pissi is usually applied to soft wheat and kathia to hard, but the two kinds are often mixed in one field.

Barley. Hordeum vulgare. Vernacular, **Jau.**

While growing barley has a strong general resemblance to wheat, but the arrangement of the grain on the ear is altogether distinct, and there is a kind of frill at the point where the leaf separates from the stem that makes it easy to distinguish it in the early stages. It is grown at the same season as wheat and generally in the same way, but with less labour and expense. Thus it gets fewer ploughings, less manure, less water (being much more frequently grown without irrigation), and it very commonly follows a kharif crop in the same year. Weeding, too, is much more rarely done and the crop is generally found growing on poorer soils than wheat; thus in all these respects it is a second-class crop. Accordingly it is most commonly grown in the Benares division and least in the wheat districts of the west. The outturn of grain is rather higher than in the case of wheat, but a large proportion of this is the husk, which adheres to the grain when being threshed, and has to be removed in grinding.

Irrigation being rarer, barley is much more dependent than wheat on winter rains, and if these fail entirely the outturn may be very poor. Excessive rain may involve very serious injury from rust.

Barley is not very much sown alone : we have seen above that it is sometimes mixed with wheat, but most commonly it is grown along with gram or peas, or both, when the mixture is known as bejhar, or bijhra, as well as by other local

names. The produce of the mixed crop supplies a great portion of the food of the poorer classes.

Oats. Avena sativa. Vernacular, **Jai.**

Oats belong to the same class of crops as wheat and barley, but unlike them are a recent introduction to the provinces, and are grown only in a few localities; the grain is not eaten by the people to any extent, but is given to horses, and the cultivation is of importance only in a few parts of Meerut and Rohilkhand. The seed will germinate in a colder and moister seed-bed than wheat, and the crop can sometimes be sown with good results as late as December on the cold heavy soils that have been too wet to sow anything in October or early November. If the crop is irrigated copiously, it can be cut once or twice for fodder, and finally left to mature its grain, but in these circumstances the produce of grain is greatly reduced. When grown for grain alone the produce may be as much as 1,500 lbs. per acre. The tillage given is generally similar to that for barley.

Gram. Cicer arietinum. Vernacular, **Chana.**

Gram is the principal rabi pulse of all parts of the provinces west of Allahabad. It is a low-growing feathery plant with small flowers, usually pink in colour, and holds its grain in small pods more or less globe-shaped, not long and narrow like the kharif pulses or peas. It appears to be suited by a warmer seed-bed than either wheat or barley, and is always the first crop to be sown: sowings often begin in September and go on till the middle of October in ordinary years. It is often sown by itself, and also mixed with wheat

and barley, as has been already mentioned. The heavy soils suit it best, but it grows on almost all, and does not require a very fine seed-bed: in fact it may be seen growing fairly well among the heavy clods of rice fields that have merely been hurriedly broken up with the plough. It is rarely irrigated except in very dry seasons, and in the Meerut division; weeding is very seldom needed, but a common practice is to nip the tops of the young plants before they flower, the result of which is to make the plants bushier, and it is believed to increase the quantity of grain. Harvesting and threshing are carried out in the same way as with wheat: the outturn averages about 700 to 800 lbs., which may rise to 1,000, or even more.

The gram crop is apt to suffer a good deal if anything occurs to interfere with the regular routine of sowings. Thus in 1896 after an entirely dry September the people first concentrated their efforts on sowing wheat, and sowed the gram later, but by the time they did so the ground was apparently too cold and the crop was poor from the first. Again, when there is heavy rain in October, the early sown gram may be destroyed, while the ground is so much chilled by the rain that what is sown later does not germinate properly. Being unirrigated the crop depends very largely on a fall of rain in January, but it is not an entire failure even if the whole season is dry. Frost when the plants are in flower does a great deal of harm, and caterpillars may in damp years cause much loss both by eating the leaves and by boring into the pods and eating the grain. It does not appear to be affected seriously by any fungus.

There are several varieties differing mostly in the size and colour of the grain: one of these, known as Cabuli,

has a large white seed, and is a very handsome plant, but it has not proved so suitable for these provinces as the ordinary kinds, the produce of grain being considerably less.

Peas. Pisum arvense, and Pisum sativum. Vernacular, Mattar.

Two species of field peas are grown, to some extent all over the provinces, but mainly in the districts east of Allahabad. Like gram they are sown early, by preference on the heavier soils, and often mixed with barley ; but apparently a cooler seed-bed is desirable, as peas are sometimes substituted for gram when early October has been wet ; this would also explain why peas take the place of gram in the agriculture of the eastern districts, which usually get more rain late in the season. The cultivation is generally similar to that of gram, but irrigation is much more common. The outturn is higher than that of gram, rising to 1,100 or 1,200 lbs. to the acre.

Peas suffer greatly from frost, but in the eastern districts, where they are most largely grown, the danger of this is much less than further west. They also suffer from the bahadura and other caterpillars. In the east peas, or mixed peas and barley, are the first crops to ripen, and are often harvested at the earliest possible moment in February, when the stock of kharif food is already beginning to run low.

Lentil. Ervum lens. Vernacular, Masur.

This is an inferior pulse, rather similar in appearance to gram but not so bushy, and with smaller and narrower leaves, and a purplish flower. It does best in low-lying damp clays, and is found most commonly in the tarai and

submontane tracts. It gets very little tillage, being often sown in rice fields while the rice is still standing: it is practically never manured and seldom irrigated, and the outturn is little over half that of peas.

Kasari. Lathyrus sativus.

This is the lowest of all the rabi pulses. It is grown only where the people are poorest, that is to say, in the eastern districts and parts of Bundelkhand, and in them only on the worst land, such as wet clays, rice fields, and tank bottoms. It has thin leaves ending in tendrils, and climbs when there is anything to climb on: the flower is pink and blue; the seeds, which are like flattened peas, are borne in short, narrow pods. The tillage is of the roughest, and manuring or irrigation are apparently unknown.

The grain is eaten by the poorest classes: it has been found to contain some drug that produces paralysis if consumed in large quantities, and wherever it has suddenly come into general use on the failure of other crops epidemics of paralysis have been observed to follow.

Potatoes. Solanum tuberosum. Vernacular, Alu.

The potato appears to be a fairly recent introduction into the provinces: it is grown mainly round the larger towns, but is spreading to the small towns and villages, wherever there is an assured supply of water and manure. The land gets thorough tillage, usually being dug over with the phaora as well as ploughed frequently, and very heavy dressings of manure are applied, often in the form of poudrette. The potatoes are planted in ridges, between which water is allowed to flow at intervals of a week or ten

days from November to January, and the crop is usually ripe by February, when the roots are dug. No crop seems to respond more directly to heavy dressings of manure, and ten tons or even more of roots may be taken off an acre; but a cultivator has to be fairly prosperous to afford enough manure to make anything like this outturn possible, and probably six tons is a good crop in ordinary circumstances.

Potatoes leave the land beautifully clean for the next crop, and there is usually a good deal of manure left in the soil: maize is very commonly grown in the following season, but in Farrukhabad, where the cultivation is very extensive, tobacco is grown immediately after the potatoes, then maize, and then potatoes again, or three crops in a year.

The crop is grown only where an ample supply of water is assured, and therefore does not depend on the winter rains. It is liable to a well-known fungus, the potato blight, but this has not as yet done any very widespread damage in these provinces.

The highest class potatoes grown in the provinces are obtained in the hills near Naini Tal, and seed potatoes obtained from there can be raised successfully in the plains, but the seed is too expensive for the ordinary cultivator. The potatoes he usually grows are smaller, and have less flavour. The use of this food among all classes is said to be increasing.

CHAPTER XX.

THE PRINCIPAL CROPS.—RABI NON-FOOD CROPS.

The rabi crops to be noticed in this chapter comprise three oil seeds, two drugs and one dye, but oil is also obtained

from one of the drugs and from the dye. No fibre crop is grown in this season.

Rape or mustard. Brassica campestris. Vernacular, **Sarson, lahi.**

There are numerous varieties of rape or mustard bearing a strong general resemblance to each other. It is a plant with broad leaves, grows as high as five or six feet, and has small but conspicuous yellow flowers ; these are succeeded by long green pods, which contain the seed. The varieties spoken of as sarson are very seldom grown alone, but all over the provinces are to be seen in the fields of wheat, barley and gram, where they are sown either broadcast with the other crops or in lines through them. The plants usually grow quicker than the wheat and get ahead of it : if they grow so rank as to smother the wheat, or if there is a scarcity of fodder, some of them are pulled up while green and given to cattle as fodder ; the rest are left until the pods are ripe, when the plants are gathered and the seed trodden out in the usual way. Sarson ripens some time before the other crops with which it is sown.

The varieties known as lahi are usually shorter in growth than sarson, but otherwise resemble it; they are very little grown except in the submontane districts, where they are sown by themselves in October, and ripen usually in February. The outturn in this case is about 500 to 600 lbs. to the acre.

The great danger is damp, cloudy whether while the crop is growing, as the small green aphis known as mahun spreads with enormous rapidity in such weather, and sucks the sap

out of the plants : this danger makes rape a speculative crop to sow by itself.

Rape-seed is one of the great articles of export of the provinces, but a great deal of the produce is consumed locally : in this case the oil is pressed by the teli as in the case of til, and is in great demand for cooking, and also for burning. The cake is a valuable food for cattle.

Linseed. Linum usitatissimum. Vernacular, **Alsi.**

This plant is largely grown in Europe for its fibre, which is known as flax, but in India it is grown only for seed : the European type of plant is a single long stem, while the Indian plant has a number of short branched stems, and consequently bears more seed but shorter and weaker fibre. The English type of flax can be grown in parts of the country, but there is no local market for it, and fibre is never extracted from the country plant.

The plant is distinguished by its bright blue flower, which may be seen growing round gram and other rabi fields in many parts of the provinces. It does best in heavy clay soils, and is grown alone to a considerable extent in the black soils of Bundelkhand and in the rice districts ; elsewhere it is sown as a border or in lines with other crops. In Bundelkhand it is cultivated with some care, getting three or four ploughings, but in the rice districts the seed is often scattered on the damp rice-land and ploughed in roughly. Irrigation is rarely given, and the plant needs no attention till it is ripe, when it is pulled up and the seeds beaten out of it. The oil is pressed out of them in the usual way, and the cake is an excellent cattle-food, and is occasionally eaten by the poor. About 500 to 600 lbs. of seed are got from an

acre when the plant is grown by itself. A great deal of the seed produced in the provinces is exported to Europe.

Linseed suffers very heavily from a fungus when the season is damp and cloudy : the fungus has a general resemblance to rust in wheat and appears to thrive under the same conditions ; it is one of the plagues of Bundelkhand that two of its few rabi staples are liable to injury from a single abnormality in the weather.

Duan. Eruca sativa.

This is a medium-sized plant with long leaves and yellowish flowers, which are followed by a row of short pods or capsules running along the stem of the plant and containing the seeds. It is grown most commonly in the west of the provinces, but is rarely sown alone ; it is usually sown as a border or mixture with barley and gram, and is sometimes sown roughly among the stalks of a cotton field. The seeds ripen ordinarily in March or early April, and the oil is extracted from them in the usual way. The stalks and leaves of the dry plant are of no use, but if cut while green they can be used as fodder.

Poppy. Papaver somniferum. Vernacular, Posta.

The different varieties of poppy grown for the drug known as opium which they produce are all distinguished by their large white flower ; red or purple flowered varieties are grown in Central India, but they do not suit the climate of these provinces. No one can grow poppy without a license from Government, and the licensees are bound to deliver the whole produce to the Government agency. They are able to get loans on favourable terms to meet the cost of growing

the crop, which is in consequence very popular with them provided they feel sure of good treatment from the subordinate officials of the department.

Poppy requires a great deal of labour for its cultivation; it is usually sown in heavy loams or light clays and in rich manured land, which is ploughed as often as time allows. The seed is sown rather later than the ordinary rabi crops, and a watering before sowing is very often necessary. When the plants come up a top-dressing of saltpetre or powdered dung and ashes is often given, while it is a great advantage if the field can be watered from a well near a village site containing nitrates which have come into it out of the soil. Frequent light waterings are necessary, sometimes as often as once a fortnight, and the field must be kept quite free from weeds. Growth is slow until February, after which it is very rapid, and as the petals begin to fall from the flowers they are collected and pressed into cakes, which are used for packing the opium. After the petals have fallen the seed capsules swell up and the drug begins to form inside them; in order to collect it small scratches are made in the capsules with an instrument like a comb; this is done in the evening, and by the next morning some gummy juice is found to have collected where the capsule was cut: this is the opium, and it is carefully scraped off and stored. Each capsule is lanced several times before all the opium has been got out of it, and considering the large number of plants in a field it is obvious that this work is very laborious, while it demands a very delicate touch, which can be acquired only by practice. When nothing more can be got out of the capsules, they are cut off and the seeds they contain sold for oil-manufacture, while the capsules themselves are bought

by druggists for use as poultices or in fomentations. Much of the seed is exported to Europe, where there is a demand for the oil.

The outturn of the crude opium is believed to be about 20 lbs. to the acre ; all of this should be handed over to the Government agency at whatever price has been fixed, but it is only natural that the cultivator should keep a small supply of the drug for himself and his friends, and he is generally suspected of doing so.

Caterpillars occasionally do a good deal of harm to the young plant by eating off the leaves : it does not seem to be seriously affected by fungus, but the formation of the drug is very much dependent on the weather, and an east wind with damp air while the capsules are being lanced results in very serious loss.

Tobacco. Vernacular, **Tambaku or surthi.**

There are two species of tobacco grown in the province. The commonest is *Nicotiana tabacum* or *desi tambaku*, a tall shrub growing from four to six feet high with enormous smooth, pointed leaves and pinkish flowers: the other, *Nicotiana rustica* or *Calcuttia tambaku*, is a lower plant with branching stems, rounded, crumpled leaves, and pale yellow flowers. Both alike are grown only in the most heavily manured fields, and especially where the well-water contains nitrates. As a rule the seedlings are raised in nurseries and planted out during October, when the crop ripens in February ; in other cases the seedlings are planted out in February and the crop harvested in May. In either case the soil is thoroughly tilled, usually with the phaora, and the seedlings planted out while it is moist. The plants need a great quantity of

water, and irrigation may have to be done as often as once a fortnight: the land has to be carefully weeded, and all buds are picked off the plants as they form and the leaves thinned where they are too numerous. When the leaves are ripe they are picked and left on the ground to wither: then they are piled in a heap and left with an occasional sprinkling of water. In this state they ferment, and after a month or so they become pliable and are twisted into ropes for sale. The process of fermentation is the work of very minute living beings, and it is largely by attention at this stage that high-class tobacco is produced in other countries: in these provinces the fermentation appears to be left to chance, but the product obtained is suitable to the tastes of the people.

Tobacco planted out early may be seriously injured by the slightest touch of frost, while that planted later is liable to be ruined by a hailstorm: it is not much injured by insects or fungus in these provinces.

Safflower. Carthamus tintorius. Vernacular, Kusum, barre.

Safflower is an upright prickly plant with conspicuous yellow flowers. It is grown in Meerut and also in Benares, but comparatively little in the intervening country; it is usually sown along with gram or other rabi crops as a border or in lines. The flowers are gathered for the sake of the dye that is made out of them, a beautiful pink colour. After the flowers have been gathered seed is formed on the plant and is collected and used either as cattle-food or for extracting oil.

CHAPTER XXI.

THE PRINCIPAL CROPS.—CROPS SOWN AT SPECIAL SEASONS.

We now come to the third main division of crops, those which are sown at special seasons. By far the most important of these is sugarcane, which we shall notice first.

Sugarcane. Saccharum officinarum. Vernacular, Ukh or ikh.

Sugarcane is grown all over the provinces except in Bundelkhand, where it is almost unknown, but to a large extent it is localised. The principal cane tracts are (1) the country from Saharanpur to Bulandshahr, (2) the Rohilkhand division (especially Bijnor), and (3) the eastern districts and the adjoining parts of south-east Oudh. The seed-time varies : in the west it runs from January to March, that is, before the rabi is harvested, while in the east it is more usually sown after the rabi harvest is over, that is to say, March or April. The crop as a rule gets the very best care of the cultivator, and its growth is the high-water mark of his art. The soil is usually either good firm loam or light clay. Ploughing begins in August, or in October if an early kharif crop has preceded the cane, and goes on steadily till sowing time ; and heavy dressings of manure are given. The cane is propagated by means of cut pieces of the preceding crop, not by seed as the term is ordinarily used : the cuttings are placed in furrows in the ground and covered in with the plough, and from this time the land requires constant watering and hoeing until the rains break, the hoeing being done with a tool resembling a small

pickaxe, which breaks up the soil to a depth of six or eight inches, doubtless with the object of reducing evaporation as much as possible. Once the rains have come, the crop is left to itself, though it must be watered again in long breaks or when the rains have ceased early. It is usually ripe about December in the west and from January onwards in the east; in this instance the term "ripe" does not denote that seed has formed, but that the plant has just reached the stage where the quantity of sugar in the juice is at a maximum. If left standing after this point, the plant begins to use up the sugar again for its own nutrition, and some varieties occasionally send up a long feathery flower. This happens to a much greater extent in some years than in others, and when it occurs commonly it means a serious loss, as most of the sugar has gone to form the flower. When ripe the canes are cut and stripped of their leaves, and the juice is pressed out and boiled down to sugar. We need not describe these processes in detail; a full account of them would take up excessive space and the information is available elsewhere.*

Cane is certainly a speculative crop. It is fairly safe during the ordinary hot weather as provision has been made beforehand for its irrigation, but when the beginning of the rains is delayed and a period of intense hot weather sets in during June and July serious loss results, as the evaporation from the soil is so great that it is very difficult or even impossible to keep the land sufficiently moist. Long breaks in the rains too do much harm: the period from June to September is that during which the growth of the plant is greatest, and any

* See "The Sugar Industry in the United Provinces," by S. Muhammad Hadi, published at the Allahabad Government Press.

hindrance to growth in those months cannot be recovered. On the other hand cane can stand a considerable excess of water without suffering much injury, but where it has been sown in lowlands without irrigation long continued floods may destroy it. We have already mentioned the cane-borers which may do so much harm, and the still more serious rind fungus ; caterpillars and grasshoppers also injure the young plants, and jackals have to be watched for when the cane is mature. Pigs are also a source of danger: white-ants too are ruinous to the cuttings when first placed in the ground.

The outturn of the crop may be roughly put at from 25 to 35 maunds of gur to the acre, gur being the commonest form of sugar produced : it varies greatly with the kind of cane, with the season, and also with the skill of the cultivator, and it cannot be estimated with any degree of certainty from the look of the standing crop, for it often happens that large canes full of juice may have comparatively little sugar in them, while thin dry canes may be very rich. The crop pays very well to a man who knows how to grow it and who with his family does as much of the work as possible ; grown by hired labour or by an ignorant man it is usually an unprofitable venture.

The number of varieties is very great, and many of them appear to be very much localised, that is to say, a variety that does admirably in one district may be almost a complete failure a little way off. Most of the canes grown for sugar are thin reedy-looking things, quite different from the stiff thick canes that are seen in other countries : where thick canes are grown in these provinces, sugar is very rarely made from them, nor would it pay to do so with the

ordinary appliances. They are in great demand as a fruit; these thick canes are known as paunda in contradistinction to the thin canes or ukh: canes of an intermediate thickness, known as ganna, are grown in parts of the western districts for their sugar. Paunda is usually to be found in the rich garden land close to towns. It is much more expensive to grow than the ordinary canes, requiring more water and very much more manure, but it is exceedingly profitable owing to the high price that is paid for the fruit.

Chehna. Panicum miliaceum.

Chehna is a small millet exceedingly like sawan, and in fact it is called sawan in parts of Oudh, where it is most largely grown, but it is a distinct crop. It is grown in Bundelkhand as a kharif crop, but in the rest of the provinces it is sown in the period from February to April: it is common in parts of Meerut and Agra, but south-east Oudh is its great home. It has to be watered constantly, and does much better with well water than when watered from the canal; in fact its whole existence may be summed up in the one word water. It ripens inside of two months, and is harvested like the other small millets, giving a yield of from 400 to 500 lbs. to the acre.

The growth of this crop involves very heavy work on the bullocks that raise the water and on the cultivator himself, at a season when even a bullock feels the heat severely, and its value lies in the fact that it brings in a fresh stock of food for the household; thus the extent of its cultivation depends largely on the previous harvest: where the crops have been good and the cultivator has something in hand he saves his labour and his cattle, but when his store is

short, he sets to work to replenish it. Consequently it is in a famine season that the crop is most grown: in 1897 after the great loss of the kharif and with a reduced rabi area the people in south Oudh set to work and grew amazing crops of sawan all through the hot weather; and there is no doubt that the crop helped greatly to ease the pressure of scarcity.

Melons.

Very many kinds of melons are grown in the hot weather: the ordinary melon is known as kharbuza, while the water-melon is called tarbuz. Many of them are grown in small patches of highly manured land where they can be constantly watered, but the most striking method of growing them is the use of the coarse sand of river-beds. Where the sand is entirely barren holes are made in it and filled with manure, in which the plants are sown, while if the sand is finer less manure is used: in either case the wetness of the sand due to the neighbourhood of the river is the great point: melons require an enormous quantity of water, and they get it in this way with a minimum of labour. Melons grown in this way begin to ripen in April, and the crop continues till ended by a flood on the river, which submerges the ground. Water-melons are sown rather earlier than the other kinds, and ripen in the beginning of the hot weather.

The large number of plants allied to melons and known generally as gourds or as cucumbers need not be described in detail: they are sown and come into the market at varying seasons during the hot weather and rains, and add materially to the food supply when it is short. In 1897 they were sown very generally throughout Oudh, as was

chehna (see above), particularly in the maize fields, where they grew between the young maize plants and were ripe in a month or six weeks.

Singhara. Trapa bispinosa.

This is a water plant, growing in tanks and ponds with its roots in the soil and its leaves floating on the surface of the water. The young plants are raised either from seed sown in the cold weather or from cuttings of plants that have survived from the previous harvest : these have to be planted out under water and fixed to pegs driven in the mud. The leaves soon form a dense mat on the surface of the tank, and the cultivator goes round on a boat or raft and gathers the nuts as they ripen. There is of course no tillage, but the plants while growing have to be watched very closely for the appearance of insects, and any that are seen must be picked off.

The nut is dark in colour and looks rather like a chestnut : the kernel is eaten both cooked and raw, and it is also made into flour. The cultivation is carried on almost entirely by kahars and similar castes, who are at home in the water, and they make a very fair profit out of it as the nut is in great demand.

Carrots. Daucus carota. Vernacular, Gajar.

The Indian carrot is different from that which is familiar to Europeans as a vegetable : the root is dark coloured and is coarse and flavourless. The seed is usually sown in September, and a large field of carrots is rare, odd corners of land and the waste patches near a well being most commonly used. The root is ready for digging in about two months afrer sowing. Carrots therefore like several other

crops in this section form a great resource when the kharif has failed, as small patches can be grown with irrigation and add to the food supply for the winter ; the seed always rises to a very high price in a famine season as the stock is strictly limited, and seed freshly imported from other countries is apt to be a failure. Like all other crops which are grown for their roots, the tillage should be deep so as to give the roots space to grow to their full size, and the land is often dug with the phaora instead of being ploughed.

Radish. Raphanus sativus. Vernacular, **Muli.**

Radishes are grown for their bulk, and may be anything up to a foot in length : the seed is sown in August or September, and the roots are ready for digging by October or a little later according to the season. Depth of tillage is necessary to get them of their full size.

This is another crop which comes in very usefully when the kharif is a failure, but in this case also the supply of seed is quite inadequate in such years, and of course the seed of the diminutive European radish would be useless.

Indigo. Indigofera tinctoria. Vernacular, **Nil.**

Indigo is a shrubby plant with numerous small leaves, which is grown almost entirely for the dye that can be obtained out of the leaves and stems. It was at one time a most important crop, as this dye could be obtained only from India and a few other countries, and there was no good substitute ; consequently its cultivation extended rapidly wherever a factory was set up. We have already indicated the abuses to which these factories gave rise in certain circumstances, and the interest of the matter is now mainly historical. Falling prices for some years led to a contraction

in the area sown as factories failed and were shut down, while in the last few years methods have been discovered of manufacturing the dye itself, which threaten to kill the growth of the plant altogether, or in any case to reduce production still further.

Where canal water is available, and in some of the damper eastern districts, the crop is sown in April: it gets on with rather poor land and rough tillage, but the seed-bed must be thoroughly moist, and the land must be watered before and after sowing until the rains set in: the plant is ready for cutting in August, when it is just about to flower, and is reaped with sickles and carried at once to the factory. Where water is not available, the crop is sown at the beginning of the rains, and is ready for cutting in September. When the crop is grown for seed the plants stand over till December, when the seed ripens.

Indigo depends very much on the weather at the beginning of the rains: where the rain is excessive it grows tall and woody and the quantity of dye in the leaves is very much reduced, so that growers who can get canal water prefer even scanty rainfall to the slightest excess.

Pan. Piper betle.

This plant is a climber with large leaves, which are used by many classes for chewing. It is grown only in the damper districts, and even there the ground has to be kept constantly moist and the plants sheltered from the wind: this is effected by growing it in a kind of hot-house made of bamboos and wicker screens, which is usually erected on the bank of a pond, and hence forms a conspicuous object in the flat landscape. The cuttings of the plant are put into the ground about March, and are covered with wet

grass till they have made a start: they have to be irrigated constantly and are manured with pounded oil-cake and tended with continuous care. They last for some years, leaves being picked off from time to time for sale.

Kachiana.

Finally, to complete this brief summary of the crops that are commonly grown we must mention the numerous herbs and spices which are conveniently described as garden crops or kachiana. Near most large villages a few patches of land are usually to be found where small plots of a great many crops are growing side by side, including pepper, turmeric, ginger, onions, a large number of herbs used as green vegetables, and various plants that yield spices or drugs of one kind or another. These patches of land are constantly manured and watered, and are never bare of crops: the kachis or men of other castes in the same grade are exceedingly clever gardeners and raise all that the village requires. And when they come within reach of a foreign demand, they accommodate themselves to it with considerable aptitude; thus the Lucknow gardeners have specialised in strawberries, peas and tomatoes. The gardener of this type shrinks from no amount of minute labour, giving each individual plant just what it seems to need; he never stints manure, and will pay almost any rent rather than leave his bit of land when he has got it into order. Such a man prefers to start on a light well-drained loam, or even fairly consistent sand, but whatever land he has to work on is soon transformed by the amount of manure applied. A detailed description of the crops he grows aud the methods he follows would be of interest only to specialists.

CHAPTER XXII.

GROWTH OF TREES FOR FRUIT AND FUEL.

Difference between trees and field crops.

Nearly all the plants with which we have hitherto been concerned produce their seed in the year in which they are sown, and then die: trees differ from field crops in that, while they obtain their nourishment from the same sources, they go on growing for many years, yielding their seed year by year. Sometimes the seed itself, or the fruit in which it is enclosed, is a valuable product, while in other cases the seed is almost worthless and the tree is grown for its wood or some other part of its perennial structure. In the first case the tree gives a more or less steady annual income, while in the second it gives no direct income until it is cut down.

Some trees are almost everlasting, living for the space of several human generations, while others cease to grow and eventually die in a comparatively short period: and as a general rule the trees that are quickest in reaching the fruit-bearing period are also quickest to decay. Now it is obvious that if a tree will give no return for a long period of years, it is not an investment into which the ordinary cultivator can afford to put much money or labour; and consequently he is concerned mainly with fruit trees, while the maintenance of the fuel and timber supply is naturally the business of the landholder. But where competition for land is keen, that is to say, where rents are high, the landholder can get a higher immediate income by letting all his culturable land than by growing fuel on it, and as a matter of fact little land in the more developed parts of these provinces

is devoted to this purpose. In the thinly populated tracts lying in and near the hills, the land is under forests which are for the most part managed by Government, and which supply most of the timber that is used for building in towns or for other similar purposes. They also supply fuel to the people living in their neighbourhood, and they could supply a very much wider area if it were not for the fact that the cost of conveying it to the cities raises the price to a prohibitive figure. Thus most of the country depends for its fuel on dung, supplemented where possible by the branches and loppings of the trees that grow singly on the field boundaries and on the unculturable land : these trees also supply most of what is used in the construction of agricultural implements and in building houses in the villages ; the great resource is the babul or kikar, which springs up in odd corners all over the provinces.

Fruit trees.—Guava.

The variety of fruit trees is not very great. Of the quicker growing kinds the commonest is the guava, which is grown in orchards and never reaches the size of a large tree. Each tree is carefully watered and often manure is dug in round the roots, and for a few years a very heavy crop of fruit is obtained annually. As soon as the trees begin to give poor yields it is best to cut them down and plant new ones in their place.

Oranges, &c.

A number of varieties of oranges, limes, and lemons are grown in orchards in much the same way : the fruit of nearly all the local varieties is of poor quality judged by European

standards, and the art of pruning seems to be almost unknown. This art consists in cutting away some of the branches of each tree, so that the energy of the plant's growth may be concentrated on a comparatively small surface ; when properly done it adds greatly to the weight of fruit borne by the tree, but it is an art that has to be learned by practice.

Mangoes.

Of large fruit trees also the number of kinds is very small, but one of them, the mango, is grown in almost every village, and is more important as a source of food than all the other trees put together. Mangoes have to be distinguished into two kinds, the country mango, which grows freely over most of the provinces, and the mangoes of superior flavour, which have been brought from other parts of India, and are usually propagated by the process known to gardeners as grafting. These superior mangoes are grown in the gardens of the richer classes, and occasionally by market-gardeners : there are numerous kinds distinguished from each other by the flavour of the fruit, as well as by its size, colour, etc ; the trees are usually shorter-lived than the country mango, and to fruit properly they often require a liberal supply of water round the roots and a dressing of manure dug into the ground.

The country mango on the other hand is easily raised from seed by sowing the kernel of the fruit ; it makes a tall, handsome tree, which begins to bear fruit within about ten years of being planted, and continues to bear for about a generation or even a longer period. It will grow in most

soils except the stiff clays and the shifting sands, but it seems to do best on the light loams and firmer sands, and after a few years it does not need water, though a watering is sometimes given round the roots to increase the supply of fruit. In a favourable year the crop is very heavy, and the fruit makes a material addition to the food supply of the country; indeed the poorer classes live mainly on it for some weeks in May or June. The crop is, however, by no means a certainty, and in fact it is rare to have two good years running: the commonest danger is perhaps the small fly that appears in enormous numbers when early March is damp and cloudy and pierces the shoots of the tree just above the flowers. The sap that should go to form the fruit runs out through the holes so made, and little or no fruit sets. Another danger is the occurrence of storms before the fruit is ripe, as much of it is blown off the tree. The green fruit is, however, not wholly wasted, as it can be made into pickles or preserves, of which a great variety is known to the people.

Mohwa.

Next to the mango the mohwa is the most important of the larger fruit trees. It grows wild over large areas in Bundelkhand, while it is regularly planted in Oudh and the eastern districts. It is rare west of Cawnpore, probably because the young trees cannot stand frost. It is raised from seed, and is usually to be found in the duab in the stiffer soils, sometimes on land that is almost usar. It grows into a tall handsome tree, but the growth is exceedingly slow and it does not fruit for many years. Once started however it gives a very heavy yield of yellow waxy flowers,

which fall off the tree in April, and are readily eaten both raw and cooked; they are also used largely for distilling, as by the action of a ferment the sugar which they contain is readily changed into alcohol, which also receives a curious flavour, popular with the people, but exceedingly distasteful to strangers. After the flowers have fallen a green fruit is formed on the tree, which is also eaten, and the seeds that it contains yield an oil that is largely used in cooking. It is also one of the best of all vegetable oils for various industrial processes, such as soap-making.

The mohwa then is a tree of the utmost value to the country, supplying large stores of food, and sometimes in seasons when the ordinary crops have been very poor: but it is little planted nowadays. The reason for its neglect is not very easy to ascertain: in some places it is known that the landholders object to its being planted, because under the customs prevailing in Oudh a tenant who has trees is entitled to them as long as he remains in the village, and a man will rarely leave the village while he has trees in it; thus a mohwa plantation means that the family of its owner is settled in the village for two or three generations. Another reason is doubtless the time that elapses before any return is obtained: a man who plants a grove of mangoes hopes to gather their fruit, but a middle-aged man who plants mohwas hardly expects to see them flower in his life-time. The tree, however, yields such a valuable supply of food for the poor that it should not be allowed to disappear, and a grove of it is a substantial addition to the value of a moderate estate, so that its growth should certainly be fostered by all landholders who desire to improve the value of their property.

Jack-fruit.

The only other fruit tree that adds materially to the food supply of large numbers of the people is the jack, or kathal. It is a large tree with shining green leaves, and produces a great weight of fruit: the fruit is covered with a thick prickly skin, and grows out from the main trunk or the branches, a single fruit weighing several pounds. The tree is seen at its best in fairly good soil in the damper districts in the east of the provinces: in drier country it fruits much less heavily, and usually requires to be irrigated before flowering time; but where the soil suits it, it pays exceedingly well.

Other fruit trees.

We may also mention the ber, which is little more than a shrub, but is cultivated widely for its fruit: and the jamun, a medium sized ever-green tree, which yields a small plum-shaped fruit: it is of special importance in that it can be grown in marshy land such as the khadir, where mangoes and mohwas will not thrive.

Fuel trees.—Babul.

The most important trees for timber or fuel are the babul, dhak, nim and shisham. The babul springs up spontaneously in many places where land is left uncultivated, and can easily be raised from seed sown broadcast wherever the land is not absolute usar or bhur. It is a quick-growing tree, reaching maturity inside twenty years, and it pays best to cut it down in about the fifteenth year of its growth. The seed is borne in long pods, which make good food for sheep and goats: the bark

is the main supply of tannin, a substance which is indispensable for preparing leather, and of which large quantities are consumed in the Cawnpore tanneries ; the larger parts of the wood are the regular material for making ploughs and other agricultural implements, and the smaller parts make excellent fuel, either used as they are or made into charcoal. Taken all round, then, it is a tree of the greatest value, specially suited for growing on waste patches of land, banks of tanks and the like, and as it costs hardly anything to raise and gives an assured income, either in money or in fuel, it is a tree that should be constantly in the mind of the landholder or agent who is seeking to improve his estate.

Dhak.

The dhak is a crooked-growing tree with broad leaves (very commonly used as plates) and magnificent scarlet flowers, which appear in the beginning of the hot weather. It is found mainly on heavy clay, and seems to survive where not even the babul can live ; after it has grown for some years the branches are cut and sold for fuel ; the roots remain in the ground, and throw up a new set of branches, which are again cut when they have reached a fair size. This process by which a tree yields a regular supply of wood without the expense of re-planting is known as coppicing : some trees will grow up again when so treated and others will not ; and it is obvious that the point is of great importance in connection with fuel supply. The wood of the dhak is of no value as timber, but it makes excellent fuel, especially charcoal, and a good jungle of it, if not cut too often, yields a steady income to the landholder. Apparently

it is not often planted, but if a landholder has a large area of moderately bad usar it would be worth his while to try to establish dhak on it, a small area being tried at first, and gradually extended if the first planting is a success.

Shisham.

The shisham is grown mainly for its timber, the smaller branches being of course used for fuel, while the leaves, which fall in the cold weather, are also gathered and used for the same purpose. The tree grows quickly and does not require an exceptionally fertile soil; and it coppices freely, while its seeds germinate readily and send up young trees without attention: a shisham jungle therefore is very easy to maintain as a fuel supply.

Nim.

The nim will grow on worse land than the shisham, but it grows more slowly and does not coppice so well; it is therefore of less value from the point of view of fuel: it yields a small berry as a fruit, the oil of which is much used in native medicine, while the cake left after the oil has been extracted is useful as manure.

Farsh.—Bamboos.

We may also notice the farsh, a hardy tree of the same rank as the babul, which is seen mainly in the Meerut division; and the bamboo, which is common north of the Ganges, but is not often grown south of the river. Bamboos are proverbial for the variety of their uses, and they grow quickly enough to be fairly remunerative, wherever the soil is fairly moist.

Tree-planting.

Just as all trees grow much taller than ordinary field crops, so their roots extend much deeper into the soil, often penetrating for many feet. This explains why trees that have to be watered carefully during the first few years of their growth can later on survive extreme drought: their roots have penetrated so far below the surface that they are practically independent of the surface soil, drawing the moisture they require from depths at which it is hardly ever deficient. This also explains the method of planting adopted for the more valuable trees; a hole two or three feet deep is usually dug and filled partly with earth and partly with manure or decayed leaves. The plant, which has been raised from seed in a nursery, is taken up and planted in the hole, where it is at once in a position to send its roots deep down into the ground; till it has done so, it has to be watered, and the surface kept tilled to prevent loss of water by evaporation, but once its roots have struck deep it needs no further attention.

The depth of the roots, which enables these trees to survive drought, introduces a danger of its own; if the roots are unable to penetrate downwards, the tree cannot flourish, and becomes stunted in growth if it does not die outright. This is most commonly seen where a layer of kankar underlies the roots of a tree; the tree grows well at first, but after a few years the upper branches begin to look unhealthy, the growth of the tree slackens, and soon comes to a standstill, fewer fresh leaves are put out each year, and in many cases the tree withers altogether. Before making a considerable plantation it is wise to guard against this risk

by making sure that the land selected is free from kankar, and this can easily be done by using the *sit* or sounding-rod which kankar-diggers hahitually employ. To begin with a hole of two or three feet may be dug, and the *sit* used in this : if it does not disclose kankar when used to its ordinary depth of four feet, it is clear that a depth of six to seven feet is available, which is usually sufficient. If kankar is found, the holes in which the trees are to be planted should be dug down to the kankar, which should be removed ; this of course adds to the cost of the plantation by an amount that depends on the depth of the kankar, and it is always a question whether the extra expense will pay ; but so much is certain that the plantation will not pay if it rests on a bed of kankar within a few feet of the surface.

Care of young trees.

Once the trees have been planted it is necessary to see that they get enough water, but not too much. As a rule they are watered by hand when young, and the surface soil round them kept loose by hoeing, so that trees carefully looked after need never suffer from drought. It is more difficult to avoid the risk of waterlogging, which kills off trees very rapidly in their young stages : if the ground is low-lying and apt to be flooded, the trees should be planted on wide low mounds, while if there is no risk of flooding they should be level with the surface of the ground, but in no case below it. If flooding occurs the land should be drained as soon as practicable.

Young trees have also to be protected against frost and cold winds : this is most effectively done by wrapping them n thatching grass in December and keeping the grass in

position till February. The other great danger is grazing. Cattle passing by a young tree will often destroy it with a single bite, but the harm they do is small compared with what can be done by goats, which feed on trees by preference to any other kind of food. Either then the whole plantation must be protected from animals, or each separate tree must be fenced in by thorns or a mud bank. The best way of protecting trees differs from place to place, and it is almost always wisest to see how the cultivators protect their trees and to imitate their methods as closely as possible.

Trees for fodder.

The fact that cattle will feed on trees shows that they may be of use as fodder, and in fact trees may be a valuable resource in a fodder-famine : such famines occur so rarely that it would probably not pay individual landholders to grow trees simply to meet the contingency, but the fact affords an additional reason for adopting the policy of growing fuel on every patch of waste land, small or large, on which any kind of tree will grow ; and it is in the hope that landholders who read this book will insist on the adoption of this policy in their estates that we have devoted so much space to a subject more properly described as forestry than as agriculture.

Glossary.

Agaul.—A variety of sugarcane.

Alsi.—Linseed.

Alu.—Potato.

Ar.—The sugarcane borer.

Arend.—The castor plant.

Arhar.—A very common pulse (*Cajanus indicus*).

Ata.—Flour.

Babul.—A common tree (*Acacia arabica*).

Bahadura.—A caterpillar.

Baisurai.—A weed (*Pluchea lanceolata*).

Bajra.—One of the tall millets (*Pennisetum typhoideum*).

Ban.—One of the names of cotton.

Bára.—The highly manured land close to a village site.

Bári.—One of the names of cotton.

Barre.—Safflower (*Carthamus tinctorius*).

Batái.—Division of produce in order to pay rent in kind.

Bejhar.—A mixture of barley and pulses.

Ber.—A fruit tree (*Ægle marmelos*).

Bhábar.—A tract of country close to the Himalayas.

Bhadoi.—Early rice.

Bháng.—The hemp plant (*Cannabis sativa*), also the drug made from its leaves.

Bhur.—Sand.

Bhusa.—Straw trodden into small pieces, used as cattle-fodder.

Bigah.—The common unit of area. It varies from place to place.

Bijhra.—See *Bejhar*.

Chana.—Gram (*Cicer arietinum*).

Charkhi.—A pulley; a form of water-lift. Also a cotton-gin.

Cháwal.—Husked rice.

Chehna.—One of the small millets (*Panicum miliaceum*).

Chheda.—A caterpillar.

Chittak.—A weight; one-sixteenth of a ser, or about two ounces.

Crore.—Ten millions (used of rupees).

Dahi.—Curds.

Dhák.—A fuel tree (*Butea frondosa*).

Dhán.—Rice.

Dhankar.—Heavy clay.

Dhenkli.—A lever used for raising water from wells.

Dhola.—The sugar-cane borer.

Dimak.—White ants.

Doras.—Loam.

Duab.—Country between two rivers.

Duan.—An oil seed (*Eruca sativa*).

Dudia.—White wheat.

Dumat.—Loam.

Gájar.—Carrots.

Gandhi.—The rice-sapper.

Ganjar.—A tract of country in Sitapur.

Ganna.—A type of sugarcane.

Gauhán.—The highly-manured land near a village site.

Gehun.—Wheat.

Ghara.—An earthen jar.

Ghi.—Clarified butter.

Ghirái.—The sugarcane borer.

Ghun.—Weevil.

Girwi.—Rust (a disease of wheat and other plants).

Goind.—See *Gauhan*.

Gujai.—Wheat and barley grown mixed.

Gur.—A form of raw sugar.

Guár.—One of the pulses (*Cyamopsis psoralioides*).

Ikh.—Sugarcane.

Jai.—Oats.

Jámun.—A fruit tree (*Eugenia jambolana*).

Jarhan.—Transplanted rice.

Jau.—Barley.
Jhábar.—Heavy clay.
Jhau.—A river-side shrub (*Tamarix gallica*).
Jhil.—A depression filled with water.
Juár.—One of the large millets (*Andropogon sorghum*).

Kábar.—One of the Bundelkhand soils.
Kachhár.—Low land along a river.
Káchiana.—Market garden crops.
Kákun.—One of the small millets (*Setaria italica*).
Kankar.—Lumps of limestone found in the soil.
Kankut.—Estimation of the value of a crop in order to fix rent.
Káns.—A weed common in Bundelkhand.
Kapás.—Cotton.
Kasári.—One of the spring pulses (*Lathyrus sativus*).
Kathal.—The jack-fruit tree (*Artocarpus integrifolia*).
Kathia.—Hard red wheat.
Khádir.—Low land along a river.
Kharbuza.—Melons.
Kharif.—The rainy season.
Khurpi.—A hoe.
Kiári.—Compartments of a field made for irrigation.
Kikar.—See *Babul.*
Kili.—A system of raising water from wells.
Kodon.—One of the small millets (*Paspalum scrobiculatum*).
Kuári.—Early rice.
Kusum.—See *Barre.*
Kutki.—One of the small millets (*Panicum psilopodium*).

Lagor.—A system of raising water from wells.
Láhi.—Some varieties of rape or mustard.
Lallia.—Hard red wheat.
Lawâhi.—A fungus disease of sugarcane.
Lubia.—One of the autumn pulses (*Vigna catiang*).

Máhun.—An aphis that attacks mustard.

Makái.—
Makka.— } Maize.

Makra.—
Mandwa.— } A small millet (*Eleusine coracana*).

Manjhár.—The intermediate zone of land in a village.

Már.—One of the Bundelkhand soils.

Másh.—One of the autumn pulses (*Phaseolus radiatus*).

Masur.—One of the cold weather pulses (*Ervum lens*).

Matiyár.—Clay.

Mattar.—Peas.

Mijhri.—See *Kutki.*

Mohwa.—A large fruit tree (*Bassia latifolia*).

Mota.—A bed of stiff soil forming the foundation of a well.

Moth.—One of the autumn pulses (*Phaseolus aconitifolius*).

Moti.—'Thick,' used in Bundelkhand to distinguish the better rakar soil from the worse.

Mundia.—Beardless wheat.

Mung.—One of the autumn pulses (*Phaseolus mungo*).

Muli.—Radishes.

Narma.—A variety of cotton.

Níl.—Indigo.

Ním.—A tree (*Melia azadirachta*).

Nona mitti.—Earth containing saltpetre.

Paleo.—Watering land to prepare a seed-bed.

Palo.—The outlying zone of land in a village.

Pán.—Tke betel plant (*Piper betle*).

Parwa.—One of the Bundelkhand soils.

Pátah.—
Patela.— } A beam of wood used as a clod-crusher or roller.

Pátha.—A tract of Bundelkhand.

Patri.—'Thin,' used in Bundelkhand to distinguish the worse rakar soil from the better.

Patsan.—Roselle hemp (*Hibiscus cannabinus*).

Paunda.—Thick sugarcane, grown usually for fruit.

Phaora.—A spade.

Pial.—Rice straw.

Pissi.—Soft red wheat.

Posta.—Poppy.

Rabi.—The cold season.

Rákar.—One of the Bundelkhand soils.

Rámdána.—A food plant (*Amaranthus candatus*).

Rutwa.—Rust on wheat (*see Girwi*).

Reh.—Efflorescence of soda salts on the soil.

Rendi.—The castor plant (*see Arend*).

San.— } False hemp (*Crotolaria juncea*).
Sanai.— }

Sarson.—Rape or mustard.

Sawan.—A small millet (usually *Panicum frumentaceum*, but also applied to *Panicum miliaceum*).

Sehwan.—A disease of wheat.

Sém.—One of the autumn pulses (*Dolichos lablab*).

Ser.—A weight about two pounds.

Shakkarqand.—Sweet potatoes (*Ipomœa batatas*).

Shisham.—A timber tree (*Dalbergia sissoo*).

Singhara.—Water nuts (*Trapa bispinosa.*)

Sir.—Land cultivated by the landholder as his home farm.

Sit.—An iron rod used for finding kankar.

Surthi.—Tobacco prepared for chewing.

Tambaku.—Tobacco.

Tarai.—A tract of land below the Himalayas; also applied to the low land along rivers.

Tarbuz.—Water-melons.

Tari.—Low land along the Bundelkhand rivers.

Teli.—An oil presser.

Theka.—Lease of the right to collect rent.

Til.—An oil-seed (*Sesamum indicum*).

Ukh. Sugarcane.

Uparhar.—High ground as opposed to kachhar or tarai.

Urd.—An autumn pulse. *See Mash.*

Usar.—Clay too stiff to be cultivated.

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